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EDITORIAL.

ITEMS AND NOVELTIES.

An Expansion Boring Tool.—The accompanying plate represents a useful tool of this description, patented and manufactured by C. Van Haagen & Co., of Philadelphia. The plate shows the tool in perspective and sectional views.

It is adapted to all tools having either revolving or stationary spindles, such as the lathe, the various vertical drill presses, horizontal boring mills, pulley turning and boring machines, &c., &c., by attaching it to any one of the spindles of the above-named machines.

The object to be bored or turned is secured to the face-plate of a turning-lathe, or to the bed-plate of a boring machine, by any suitable appliances, and the tool is secured to a spindle, which can be fed forwards, such, for instance, as the spindle of the pocket-head of a lathe.

The tool consists of a slotted hub, F, into which is screwed a tapering shank for attachment to the spindle. Into the slot of the hub F is fitted the inner end of an arm, G, and through the latter, as well as through the hub, passes a tapering pin.

A screw or worm, D, fits snugly, but so as to turn freely in the slot of the hub F, and the thread of this worm is adapted to the teeth

of a segment, P, of a worm wheel formed on the arm G, and arranged concentrically with the tapering pin on which the worm rotates, so that on turning the worm, which in the present instance can be done by a square tool adapted to a square hole in the worm, the arm may be turned to any desired angle.

Towards its outer end the forked hub F is made slightly tapering, to receive the tapering sleeve, E, against which bears another sleeve, C, adapted to the cylindrical portion of the hub, and against the latter bears a nut, B, on the threaded end of the hub. On tightening the nut, the tapering sleeve E will be forced outwards through the medium of the sleeve C, and the two halves of the hub, which are slightly elastic, will be forced towards each other, thereby firmly gripping the arm G.

The following sizes of these tools are made by the firm:

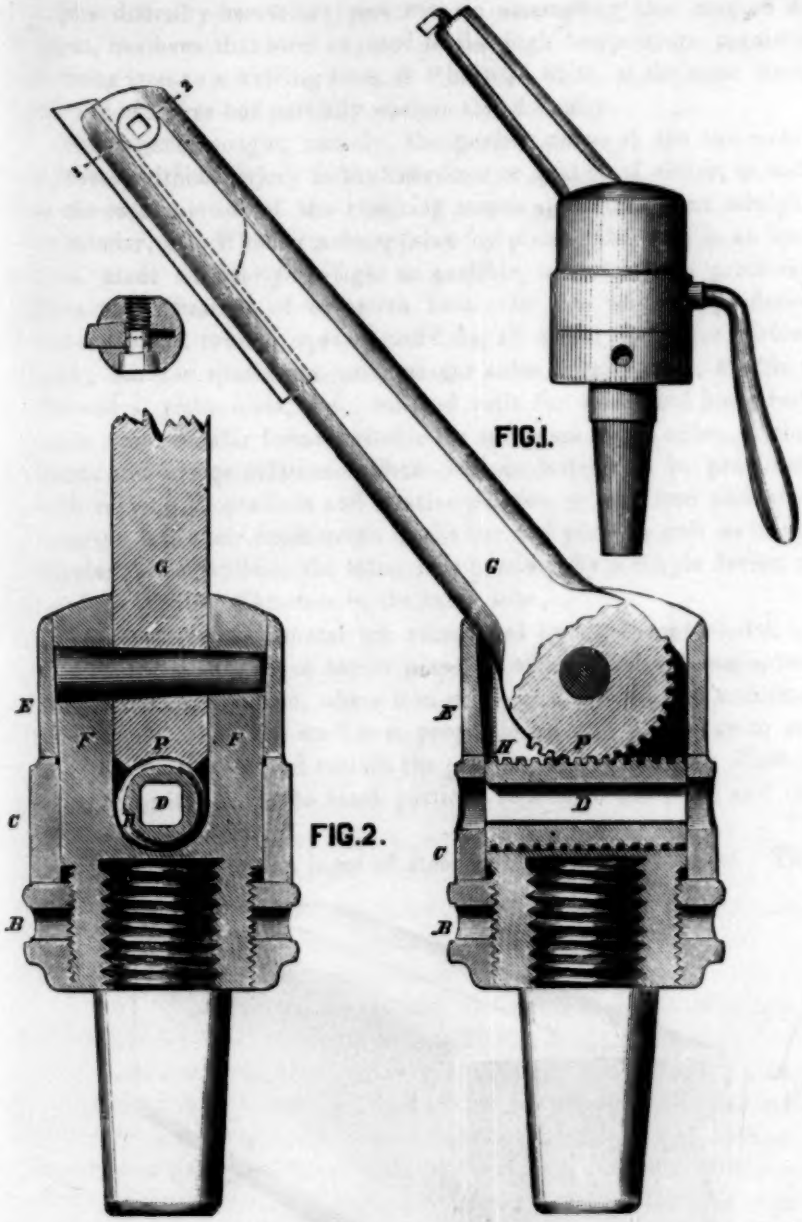
No. 1 bores from 1⅛ inches to 16 inches.
" 2 " " 1¼ " " 13 "
" 3 " " 1½ " " 11 "
" 4 " " 1 3/16 " " 8 "
" 5 " " 1 " " 6 "

This will be found a very useful adjunct tool to any machine shop, because of its universality, dispensing, as it does, with the necessity for using boring bars and cutters in a majority of cases, and the very satisfactory character of its work.

Combined Iron and Steel.—A method of combining iron and steel, which, from its simplicity, is worthy of observation, has been invented by Mr. Elbridge Wheeler. We have before referred to this process, though briefly, and take this opportunity of giving a more extended notice, with illustrations of the same.

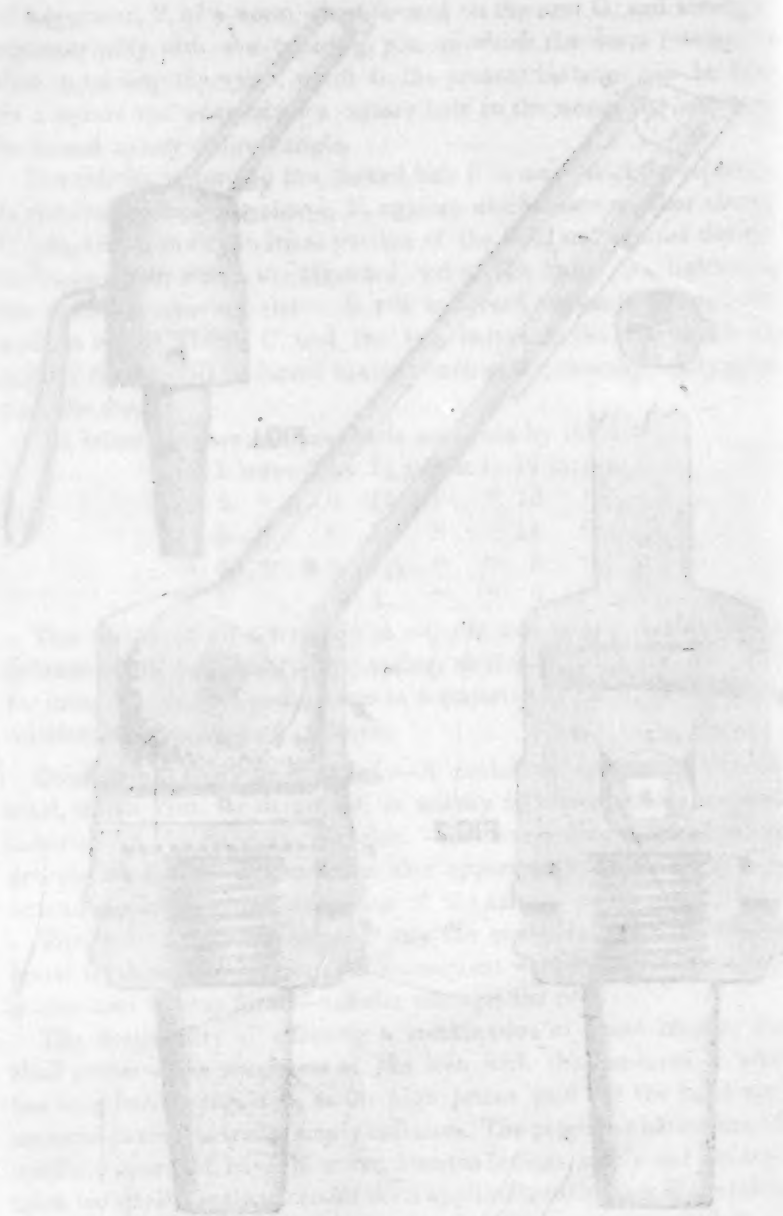
The invention embraces not only the complete union of distinct metal surfaces, but includes the subsequent working up of the combination into various forms—tubular amongst the rest.

The desirability of effecting a combination of these metals, that shall preserve the toughness of the iron with the hardness of steel, has long been recognized, as the high prices paid for the hand-made material in several trades amply indicates. The processes heretofore successfully operated, have, however, beentoo tedious, costly and generally upon too small a scale to render them applicable to the uses of the rolling mill. This desideratum the inventor claims to have accomplished, the process consisting in general terms of the uniting of iron and steel by bringing them to a welding heat in one pile and simultaneously, and then manipulating them by rotary motion.



EXPANSION BORING TOOL.

MANUFACTURED BY C. VAN HAAGEN & CO.
PHILADELPHIA.

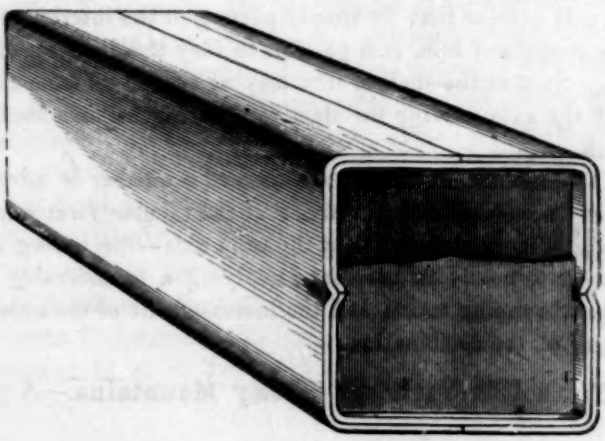


The difficulty heretofore met with in attempting this method of union, has been that steel exposed to the high temperature requisite to bring iron to a welding heat, is "burnt," while, at the same time, the use of fluxes but partially obviate this difficulty.

The objects sought, namely, the perfect union of the two metal surfaces, without injury to the character or quality of either, as well as the manipulation of the resulting combination into forms straight or tubular, Mr. Wheeler accomplishes by placing the steel in an iron case, made as nearly air-tight as possible, whereby it is protected from the influences of excessive heat. In this way are produced merchant bar, rounds, squares and flats, all sizes; plate for various uses; bar for specialties, such as car axles, wagon axles, shafting, slide-bars, piston-rods, etc.; railroad rails for steam and horse railroads; and tubular forms, suitable for such uses as car axles, marine shafts and bridge columns. These various forms can be produced, with varying proportions and relative position, of the iron and steel entering into their constitution in the bar and plate as well as in the tubular forms, while in the latter it is possible, by a simple device, to produce varying diameters in the same tube.

Three varieties of metal are recognized by the inventor—1st, an iron coated steel slab or bar or plate, in which steel predominates; 2d, a steel centred iron, where iron predominates, and, 3d, combination proper, where the steel is so proportioned and placed as to endure the most wear and sustain the greatest strain. In the illustrations herewith given, the black portions represent the iron, and the shaded parts, steel.

Fig. 1 represents an ingot of steel inclosed in an iron case. This



case is made preferably in four sections, so as to break joints at the sides, which project over the ends sufficiently to receive an end plate of iron held in place by a slight inbending of the sides. Instead of an ingot, steel slabs, cast or even Bessemer steel scraps may thus be encased. After the heating, and reduction in the rolls, to a square or flat, the resulting mass would show a bar of steel coated with iron welded to, and forming a part of it, (see fig. 2.) The coating of iron can be varied in the thickness at pleasure, according to the uses to which the product is to be put, and it is especially well adapted to subsequent forging. Fig. 3 shows a steel-centred iron bar, suitable especially for set-screws, punches, etc. Any desired proportion of steel may be used and any exterior form given to the bar.

Fig. 2.

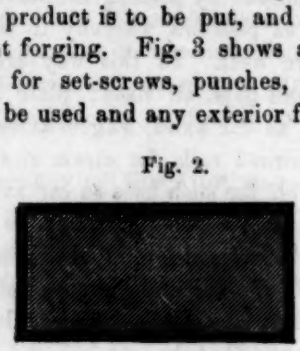
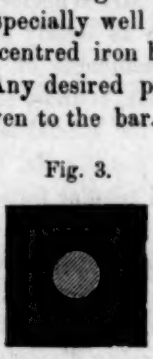


Fig. 3.



In the production of rails, the simple process of combination described above comes very admirably into play. It is, however, to the production of tubular car axles that a great field of usefulness is to be anticipated for the process. These hollow axles are produced without the aid of a mandril, by simply piling up about each other sectional tubes of iron or steel, in the proportions and positions required in the product—the piling being done in such a way as to break joints. So arranged the pile is heated and rolled, when a complete union is effected. It is clear that by simply putting in the interior of the pile smaller sections of iron, it is possible to vary the diameter of the axle at will. So that the shell of iron may be turned off from the journal ends of the axle, leaving the steel for bearing without lessening the strength.

For this tubular axle there are claimed a number of advantages—of which the more prominent are, that the tubular form affords, with less weight, more strength than the solid axle—the saving in weight amounting to nearly 25 per cent., implying a considerable saving in expense of running trains, and the increased life of the axle from the character of the combination.

A Tunnel through the Rocky Mountains.—A project no

less gigantic than the piercing of the Rocky Mountains, is announced as about to be commenced. The projected tunnel will, if completed, be carried through the Rocky Mountains from a point near Black Hawk, and will come out in the Middle Park. It is said that the project is fully inaugurated, and that its projector is on the ground with ample means and labor at disposal to prosecute the work to completion. The tunnel will be about twelve miles long. Its greatest depth will be 6000 feet, at James Park. It will make the Middle Park readily accessible from the eastern part of the territory, will indicate the mineral and geological character of the region, and will not fail to attract attention to the region, as the scene of an engineering enterprise nearly twice as difficult of accomplishment as the famous Mont Cenis tunnel.

It is stated that early next year work will be commenced from Middle Park. Already considerable work has been done.

The mountain has been graded down for the face of the tunnel; a flume, 1300 feet long, has been built from the creek, by which a fall of 25 feet is obtained for the purpose of running an overshot wheel, by means of which the tunnel is to be supplied with air; a strong levee has been built, to prevent the waters of the creek from overflowing and embarrassing the operations in the tunnel.

The main advantages to be derived from its construction are stated to be that it will open up new veins, and afford a thorough knowledge of the course of mineral veins; that it will afford a means of working the discovered mines cheaply and rapidly, and that it will develop the resources of the region by the increased facilities for transportation which its construction will afford.

The Baltimore Underground Railways.—The city of Baltimore is now in possession of a splendid underground railway system, in which respect it stands alone amongst American cities as the inaugurator of this great improvement, and which her sister cities must infallibly imitate sooner or later. There are now two distinct lines of tunnels in Baltimore, which, according to a contemporary, have been completed at a cost of nearly five millions of dollars, whereby nearly all the various railways centering in the city have been brought into connection, greatly adding to public convenience and facilitating business intercourse.

The Underground Railway consists of the Baltimore and Potomac Tunnel, of which the western portal fronts on Gilmore street, whence

it extends in a northeasterly direction through the city, under some twenty-nine streets and avenues, emerging at North avenue, where it joins the track of the Northern Central Railway.

The Union Tunnel extends from tide-water at the Canton portion of Baltimore, northerly and then easterly, under some thirteen streets and avenues, to the Northern Central Railway.

The total length of the Baltimore underground railways is 3½ miles, of which about two miles are closed tunnels, and the remainder open cuts, over which the streets are carried on bridges. The tunnel arches are from 22 to 23½ feet high, and from 26 to 27 feet wide, five rings of brick thick, backed with rubble masonry. Only a portion, where the ground was soft and springy, required the invert arch. The springs of the arches are of masonry.

Passengers can now pass through Baltimore by the new underground railway, thus shortening the time of transit from twenty to forty minutes. The tracks of the P. W. and B., the Northern Central, the Baltimore and Potomac, and the Western Maryland railways all connect with the underground railway.*

Coal-Cutting Machinery.—Comments have from time to time appeared in the technical press upon the applicability of machinery to be employed in the mining of coal. The statement is made that there are now several forms of coal-cutting machines in use in English collieries, working with great satisfaction. The machines in question work with compressed air. It is declared that the general adoption of this system of coal extraction would not only result in a very considerable diminution in the amount of waste, but would also very materially diminish the labor force now needed to keep up the extraction to market figures. So great is the estimated margin of saving on this latter score, that it is declared a force of 60,000 men only would be required to raise the 120,000,000 tons annually produced, instead of the 360,000 at present required.

The opinion, too, is very generally maintained that these advantages will be confined to localities where the veins of coal are comparatively thin. In England, for example, where the experiment has proven to be quite successful, the average thickness of the veins is from 2 ft. 4 in. to 2 ft. 10 in., while in the United States the bituminous veins range from 4 to 8 ft., and the anthracite often from 25 to 40. To this very considerable difference in the thickness of the

* Scientific American.

veins may probably be ascribed those difficulties in economic extraction which have thus far excluded the coal-cutting machine from the American mines.

Improved Method of Construction *with Metals, Glass and other Building Materials.*—The process about to be described is the invention of Mr. William Haggett, and consists in giving to the materials used in construction a peculiar form, in virtue of which the strength and adaptability of the same to civil, military and marine constructions is claimed to be much improved.

The process, in general terms, consists in giving to plain plates or sheets, of uniform thickness, of the various kinds and qualities of metals, glass, tiles and other substances, compound undulated forms, the undulations crossing each other at right angles, or obliquely, or radially and circular. These forms, it is claimed, impart to the plates great lateral strength and rigidity, and as the undulations extend in opposite directions, they afford equal compensation for contraction and expansion in all directions; a desideratum of great practical importance in construction, since, if realized, it makes it practicable to attach the borders of such plates firmly to adjacent unyielding masses.

The process for undulating the plates is varied to suit the character of the material operated upon; some by direct casting in matrices of the desired form, others by being heated and then pressed between rollers, stamps, dies, &c., but in all cases it is necessary that the alternate convex and concave parts of the rollers, &c., accurately fit and work with each other. Most rolling-mills, it is said, have all the power necessary for carrying out this system of manufacturing metals, requiring only a supply of properly formed rollers.

The following estimate is claimed to represent the strength of the undulated over the plain plates: Iron and steel about two-fifths, galvanized iron, three-fifths; sheet tin, three-fifths; brass, three-fifths; zinc, two-fifths; copper, four-fifths; lead, three-fifths; cardboard, one-fifth; while glass is nearly doubled in strength.

In construction of the ordinary kind, the plates may be attached one to the other with some overlap—the corrugations permitting of a good fit—and then attached simply at the ends. An interior wall of similar character is also erected, and the space between the two filled with some non-conducting material, which shall make the building independent of the external temperature.

It is also designed to apply the same process to the speedy erection

of forts, towers, batteries, and other works of defence, by constructing portable blocks, so formed as to interlock and become firmly bound together.

Bricks and tiles of this form are constructed and employed for roofs, sewer and wharf construction with great success. While applied to glass for skylights, illuminating panels in buildings or conservatories, there are claimed for it the several advantages of increased strength with no decrease of light, and nearly perfect absence of lateral expansion.

The above remarks indicate but a few of the numerous applications which it is proposed to make of this process, and have been selected with a view of giving some notion of the universality of its claims to usefulness.

Mechanical Stoking.—Mr. J. Somerville recently read before one of the English engineering societies a paper on charging and drawing gas retorts by machinery. The author first referred to the necessity of introducing machinery to perform labor of this kind both on account of the exhausting and demoralizing nature of the work of gas stoking, as also in consequence of the strikes amongst gas stokers, of which the recent strike in London was referred to as a notable example.

The author referred in his paper to the frequent attempts to accomplish this desideratum, mentioning the efforts of Clegg, Brunton, Michael, Green, Best and Holden in this direction. The plan described and recommended by the author of the paper consisted in an improvement upon the machine of Messrs. Best and Holden.

He employs two machines; one for drawing and another for charging, the retorts being served at both ends, and the machines following each other up in their work.

The author gave the results of working by these machines, which indicated that the cost of coking coal was 6*d.* per ton with the machine, and 1*s.* 1¼*d.* by manual labor.

English and American Railways.*—The London "Railway News" has some interesting comparisons of English and American railway returns, and in the matter of rolling stock and train earnings is surprised to find the American roads more economically run than the English. Taking four roads in each country, aggregating

* Van Nostrand's Magazine, July, 1873.

about 4000 miles, it is found that the American road has only ·33 of a locomotive and 6·72 freight cars per mile, while the English has ·93 of a locomotive and 28·83 cars. The New York Central, with a heavier traffic than the London and North Western, has half the locomotives per mile. The English refuse to believe that the superior size and strength of American locomotives account fully for this difference. The earnings, for instance, of an American locomotive are 70 per cent. more than those of an English, and the entire rolling stock, which in England barely pays for itself in a year, in this country pays for itself and 65 per cent. more. The "News" also discovers that, while passenger fares are 30 per cent. lower than in England, the earnings per train here are 4 per cent. more, and on freight trains 15 per cent. more, than on the English roads.

The Irwin Tubular Lantern.—The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination John H. Irwin's lantern, respectfully submit the following report:

They have carefully examined the lantern submitted by the patentee, and also the several specifications of his letters patent, describing the several inventions involved in the construction and operation of said lantern, and find the construction and operation of the lantern to be as follows:

An oil pot forms the base of the lantern, in the top of which is inserted a flat-wick tube, with a windlass for raising or lowering the wick, and a dome, having a slot, through which the flame rises. Thus far as described it resembles an ordinary coal-oil lamp, with the chimney removed.

The space below the dome is enclosed, so as to exclude any access of air, excepting what may reach it through the two tubes, which, rising symmetrically from the two sides of the enclosure around the wick tube, unite and terminate in an inverted funnel.

Above the flame a swinging bail, attached to the top of the air-

tubes, serves as a handle, and a globe of such size as not to be operative as a chimney is supported on a perforated plate resting on the top of the enclosed box under the dome, and extends upwards to within a short distance of the mouth of the inverted funnel, where it is held securely in position by a spring.

Around the top of the wick-tube is a small flange, projecting obliquely upwards. The wick-tube is fitted by a tapering slip joint into the top of the oil pot, and is centered in the dome by a spider or frame, secured near its upper end, fitting the interior of the dome.

The inverted funnel is of such diameter as to overhang the upper edge of the globe.

The operation of this lantern is as follows:

The oil pot being filled, and the wick adjusted and lighted, a current of air rises around and above the flame; a portion of this current enters the funnel, and is cooled, and conducted by the pipes to the enclosed space under the dome, where it is prevented by the oblique flange on the wick-tube from impinging directly upon the wick, where it might check the formation of combustible vapors or gases thrown against the interior of the dome, whence it is deflected against the flame, and issues in a current or stream, enclosing the flame and sustaining the combustion of the oil vapors and gases.

The flame does not burn by contact with air rising directly into the globe through the perforated plate, but is organized and sustained entirely in the envelope or stream of air brought down by the tubes from the funnel, and projected through the slot in the dome.

It would appear that a separation of the carbonic acid takes place from the rising current in the globe in consequence of its greater specific gravity, and upon reaching the upper rim of the globe, it there overflows and escapes. The products of combustion are discharged through the space between the globe and the funnel.

The function of the globe is merely to shelter the flame from lateral draft of air, and it does not operate as a chimney, but remains cool while the lamp is burning. The lamp, so long as there is no atmospheric disturbance, burns with a clear flame when the globe is removed. When the supply of air to the burner, through the inverted funnel and tubes, is interrupted, the flame is extinguished. This takes place whenever the lantern is overturned, or when anything is interposed between the flame and the funnel, and is a feature of safety, so far as the Committee is aware, not found in other lanterns.

When the lantern is swung to and fro by the bail, the centrifugal force of air in the tubes accelerates the flow of air to the flame, and brightens the flame.

The Committee find that when made in the proportions of the lantern exhibited, a clear, steady, and reliable light is produced without using a chimney, and that the lantern cannot be extinguished by the wind; and, further, that the principle of its operation is, so far as the knowledge of the Committee extends, novel, and the utility of the invention so obvious as to be appreciated on simple inspection, which facts your Committee think fairly establish its claim to the Scott Legacy Premium, the award of which to Mr. Irwin your Committee respectfully recommend.

WILLIAM H. WAHL, S. LLOYD WIEGAND, ISAAC NORRIS, M.D.

American Association for the Advancement of Science.—The twenty-second annual meeting of the American Association for the Advancement of Science will be held in Portland, Maine, commencing August 26th, under the Presidency of Prof. Joseph Lovering, of Massachusetts.

The St. Gothard Tunnel.—It may be of interest to note that the period prescribed for the execution of this great work is eight years, dating from October 1st, 1872. The contractor, M. Favre, has agreed to be fined $1000 per day for every day's delay. On the other hand, if he can open the tunnel in less than the time indicated, he is to receive a premium of $1000 per day.

A New Engine.—A new motor has recently been patented in this country, the operation of which is as follows: Oil is sprayed into the cylinder behind the piston, and, being mixed with air, is ignited at the proper time by an electric attachment. The consequent expansion drives the piston forward, the momentum of the fly-wheel returning it to its former position. An ejector supplies the oil from the tank to the sprayer, the ejector being connected to a piston blower driven by a crank attached to the main shaft.

The American Paper Trade.—During the year 1872 there were in operation in the United States 812 paper mills, owned by 705 firms, and of an estimated value of over $35,000,000. In addition to this actual value of mill property there is to be added the usual working capital, twenty-two and a half per cent. of the value of the

mills, thus making the total capital invested in paper-making throughout the country about $43,500,000.

The mills employ 13,420 male and 7,700 female hands, besides 922 children, or a total of 22,042 laborers, whose wages amount yearly to the large sum of nearly $10,000,000. Their product amounted last year to 317,387 tons, valued at $66,475,825. The total number of engines running is 3,293, besides 299 Fourdrinier and 689 cylinder machines.*

The Trammel in General.—By WILLIAM C. CLEVELAND, *Prof. of Civil Engineering in Cornell University.*—The well-known instrument for drawing the ellipse called the trammel has for its basis the kinematic principle that, *if two points of a right line move one in each of two right lines that intersect at right angles, every point of the moving line describes an ellipse.* That is (Fig. 1), two perpendicular lines meeting at O being directrices for the motion of A B, the path of any point, C, will be an ellipse.

The proof is as follows:

Describe a circle about O with a radius, OD = A C, and draw D C E perpendicular to O B.

The triangles B C E and O D E are similar, and give

$$\frac{CE}{DE} = \frac{BC}{OD} = \frac{BC}{AC} = \frac{OG}{OF} = \textit{constant};$$

a well-known property of the ellipse, easily made evident by taking the shadow of a circle upon a plane through its centre, the rays of light being parallel to each other and perpendicular to the intersection of the two planes; therefore C moves in an ellipse of which O is the centre.

Mr. Edward W. Hyde, my assistant, having made an analytical investigation and model of the warped surface generated by moving a right line upon two other right lines perpendicular to each other, but not intersecting, in such a manner that two of its points remain one on each of the directrices, the following general geometric solution suggested itself to me:

If a circle roll inside another circle of twice its diameter, the path of each point of the rolling curve will be a diameter of the fixed circle. (Fig. 2.)

* Paper Trade Journal.

In every position the rolling circle contains the centre of the fixed circle, and the radius, O A, to the point of contact, is a diameter of the rolling circle.

The point of contact, A, is the *instantaneous centre of rotation*, so that the path of B is perpendicular to A B; but, A O being a diameter, O B is perpendicular to A B; hence the motion of B is always toward or from the centre, O, and its path a diameter of the fixed circle.

Considering the motion of the diameter, O C, of the rolling circle (Fig. 3), O moves in the right line, A B, while C moves in the right line, C D, perpendicular to A B, therefore, by the principle of the trammel, every point of the indefinite right line, O C, describes an ellipse.

This being true for every diameter, it is true for every point rigidly connected with the rolling circle, either in its plane or out of it. Hence every point of the right line O N describes an ellipse.

But the point, N, moves on the diameter, O N, or a parallel above it, while O moves on A B.

Therefore, in general, *when two points of a right line move one on each of any two right lines, anywhere in space, intersecting or not, every point of the moving line describes an ellipse* in a plane parallel to the two directrices, the centre of each orbit being on the line intersecting the two directrices perpendicularly.

And, again, *if two points of a solid move one on each of any two right lines in space, any other point of the body being constrained to move in a plane parallel to the two lines, the orbit of each point of the body will be an ellipse* parallel to this plane, and having its centre on the right line intersected perpendicularly by all the directrices.

Ithaca, New York, December 2d, 1872.

Apparatus for Testing Petroleum Oils.—An apparatus for the purpose of testing the inflammability of petroleum oils destined for lighting purposes, designed by M. Granier, is thus described:

A small cylindrical receiver of metal is closed by a movable lid,

provided with a circular aperture in its centre. This receiver is filled to two-thirds its volume with the oil to be tested, so that there remains between the lid and the surface of the oil an air space, into which the inflammable vapors given off by the oil may diffuse. A tube, soldered to the bottom of the receiver, holds a wick, the upper extremity of which is in the middle of the aperture in the lid, whilst a thermometer plunged in the oil gives its temperature. To make a test, the oil is poured into the receiver to the height required, the wick is saturated with it and lighted. The oil of the wick burning heats the oil till the temperature is reached at which inflammable vapors are given off. A slight explosion then follows, the light is extinguished and the degree on the thermometer is read off.

There are several points of doubt concerning the accuracy of the apparatus, which may or may not be well grounded. It would appear from the description that the flame of the wick remains constantly burning in proximity to the surface of the oil, so that it would be heated from the surface downwards, and not the reverse, which is the natural process. In consequence of this, too, the surface layer of oil would be constantly hotter than those below it, and the thermometer with bulb immersed in the oil would not accurately indicate the flashing or burning temperature.

In addition to this it does not appear that the heating of the oil can be conducted with the degree of slowness which one can command with the water-bath, as it is generally employed—a condition which, as all who are familiar with the subject of testing oils are aware, is of prime importance if grave errors are to be avoided. On the whole, if the description given of the Granier apparatus is correct, it is difficult to see any points of advantage in it, and not difficult to find many faults.

The Preparations for the Centennial Exhibition at Philadelphia in 1876 are gradually maturing, and the work of arrangement intrusted to the several committees is progressing. The executive commissioner, Prof. Blake, is at present at Vienna, making personal observation of the arrangement and conduct of that great display. He had carefully investigated the Paris exposition of 1867, as shown by his work upon it; and such experience is imperatively demanded, to avoid the blunders and mistakes of previous efforts. The commission is now in daily sittings at their rooms, Walnut street near Ninth, where they have employed two secretaries and three

heads of bureaus, each of whom is entrusted with the management of some specialty. The necessity of pushing forward as rapidly as possible the preparations for the exhibition buildings is fully recognized. The location of the grounds in the park has already been selected, and plans for effecting the drainage, shading, and general decoration of the same, will be put into operation almost immediately. The statement is made that the committee on plans and architecture have decided to make use of four buildings—a central, main building, to be devoted to general exhibition purposes, and separate structures to contain the departments of fine arts, of machinery, and of horticulture. It is further stated that the appointment of the architect will be thrown open to public competition, and that all architects will be invited to contribute plans; the authors of the ten most approved designs to each receive a prize of $1000. The decision upon the successful plan will be made about July.

The Diamond and Graphite.—An important paper "On the Behavior of the Diamond and Graphite when Heated," by G. Rose, has recently been published.

From various experiments in which the diamond and graphite were burned together in a muffle, the author draws the conclusion that the leafy graphite is much less combustible than the diamond, while the solid graphite is more easily burned. He found, also, that when air is excluded the diamond may be subjected to a temperature at which pig-iron will melt, and to the strongest heat obtainable in a porcelain furnace, without being in the least affected; but at a higher temperature it is gradually transformed into graphite.

Upon the same subject, Mr. Spence, of Manchester, has made experiments which seem to prove that under certain conditions the diamond is combustible at a much lower temperature than has formerly been supposed. A South African diamond, of the size of a small pea, coated with refractory clay, was placed in a crucible with a mixture of soda and hydrate of lime, and then heated in a muffle for three days and three nights. On opening the mass it was found that the diamond had entirely disappeared, although the heat had never exceeded a cherry-red.

Editorial Correspondence.

Editor of Journal of Franklin Institute:

DEAR SIR:—The conveniences for work in both physical and chemical laboratories are multiplying. Among the best furnished institutions, as, for instance, the Stevens Institute at Hoboken, hot water, cold water, steam, oxygen, hydrogen, illuminating gas and electricity are furnished to hand by merely turning a stop-cock or a button, but the means for producing a vacuum so readily are not to be had, though quite as much needed as some of the above mentioned things.

The air pump has always had to do double work, exhausting muscle as well as the bell glass. Sprengel, Geissler, Bunsen and Draper have each contributed a modification of one idea, to lessen the labor required to produce a vacuum, and I am sure that every one who has used their inventions has felt duly grateful, yet each of these appli ances requires renewed adjustment each time it is used.

This has led me to think of a plan for having a *constant vacuum*, that shall be available on as short notice as a gas jet. Let a *vacuum tank* (misnomer or not!) be constructed with a capacity of a hundred gallons or more, which shall be kept exhausted by the Bunsen filter pump in constant action. Pipes may run from the tank to the various rooms where experimentation goes on, and connections made with rubber tube to the table where it is convenient to work. A stop-cock would be all between the vessel and a vacuum sufficiently good for most of the wants in physical or chemical experimentation. A barometer tube could be connected with the end of the pipe in each room, that would indicate, at a glance, the available exhaustion. Supposing that a better vacuum is needed sometimes, it will only be necessary to supplement with a Spengel or some other form, which is done now with the larger air pumps. It seems to me to be possible to construct a wooden tank that should furnish a vacuum balanced by less than one-tenth of an inch of mercury. I throw out this suggestion in the hope that, if it is thought practicable, it may be tried in some laboratory in the country.

Yours truly,

A. E. DOLBEAR.

Bethany College, Bethany, W. Va., July 19th, 1873.

Civil and Mechanical Engineering.

THE CONSTRUCTION OF IRON SHIPS.

(A paper read before the Franklin Institute.)

By Samuel Holmes.

(Continued from page 30.)

In the year 1853 it was proposed to build in England a steamer that would be a real Leviathan in size, and two eminent men, Mr. Brunel and Mr. John Scott Russell, took the matter in hand. The result is, the Great Eastern, of 22,791 tons, is now afloat, and doing good service as a cable ship. The proposition to build so enormous a vessel set mechanical minds thinking about the construction of iron ships, and it was apparent to the two engineers I have named that the transverse framing system was bad, and ill suited to iron vessels of length. Accordingly they severed at a blow their connection with it, and struck out anew by turning their frames around, and running them fore and aft, thus heralding in the system of longitudinal framing and constructing the strongest merchant ship afloat. John Scott Russell afterwards built the Annette, a vessel of 600 tons, and describes her arrangements as follows:

"1st. To divide the ship by as many transverse water-tight iron bulkheads as the practical use of the ship will admit. I like to have at least one bulkhead for every breadth of the ship in her length. In a ship eight breadths to her length, I wish to have at least eight transverse bulkheads.

"2d. I have between these bulkheads what I call partial bulkheads, or the outer line of a complete bulkhead with the centre part omitted, so as to form a kind of continuous girder running transversely all round the ship, and not interfering with storage.

"3d. I run from bulkhead to bulkhead longitudinal iron beams or stringers, one along the centre of every plate of the skin, so giving each strake of plates the continuous strength of an iron beam, one portion placed at right angles to another. This longitudinal forms one continuous scarph across all the built joints of the plates, hitherto their weakest part, and adds also to the strength of the rivets of the joint the help of a line of rivets and angle iron along the centre of the plate. These longitudinals and skin are therefore one.

"4th. What remains over after this is done of the superfluous iron formerly used in ribs, I make into a continuous iron deck, mainly car.

ried by the bulkheads and by longitudinals under it, and I believe this iron is infinitely better applied in a deck than in ribs fastened to the skin."

The strength of the two systems, with the same weight of iron used in each, sums up in favor of longitudinal framing, in proportion as 650 : 520, or 5 to 10, equal to 25 per cent.

Mr. Jensen, of Dantzic, in a paper on Comparative Merits of the Longitudinal and Vertical Systems of Iron Ship Building, states that in a ship 600 tons burden, the gain in weight, on a similar ship built to Lloyd's rules, was 7 per cent. and the gain in strength 10 per ct., and that if the plating had been made as thick as is required by the rules for a vessel of the same tonnage, the gain in weight would have been 8 per cent. and the gain in strength 18 per cent. on a ship intended to occupy the highest class.

Another system of construction has been tried, which amalgamates the longitudinal and transverse systems. This has been carried out in the Indian troopships, where we find the longitudinal system of framing worked in the bottom, and the vertical system worked along the sides. This arrangement ranks considerably above the transverse system, as generally carried out in the mercantile marine, in point of strength, and also has the advantage of a saving in cost. This saving, as represented, by weight amounts to 150 tons iron, in vessels of the respective classes to which these troop-ships belong, which taken at a percentage amounts to 4½ per cent.

An estimate of my own, published in the "Nautical Gazette," for a 500 tons vessel, built on the longitudinal system, shows a capable saving of 7½ per cent. on total iron, 9½ per cent. on total labor, and 10½ per cent. on coal.

As we have reviewed the transversely framed ship and pointed out its shortcomings, we will now briefly comparatively consider, with a few practical remarks, the two systems, in structure, material and labor, and endeavor to represent more exactly where and how the longitudinal system has the advantage. Supposing the longitudinal ship to be rivetted is recognizing the fact that the shell is the strength of ship; first we have a saving of material of shell in direction of likely fracture, that is, in the direction of girth of ships; for, instead of having the shell holed all round, with only a space of six inches between holes, by running the frames fore and aft we have the holes the distance of the frames, or about two feet apart, thus giving only one-fourth the number of holes round the vessel. Again: at

the bulkheads, which I have already shown to have double the number of holes that the rest of framing has, or holes every three inches apart, I propose in the longitudinal ship to give her no more holes here than in any other part of structure, by carrying the bulkheads *entirely* by a system of bracket knees, fitted at each longitudinal frame, thus giving out strength to the shell through the framing rather than reducing it one-fourth, as I have shown hitherto to have been the custom.

That the bulkheads may be water-tight, I propose to either bolt solid wood at each side, passing all round vessel's section, and caulk the edges with oakum, or build partial boxes on bulkheads, to be filled with cement, allowing the cement to harden against the bulkhead and shell of ship.

In alluding to the labor on the transverse frames, I may at once say they are *prodigal in cost*, as well as inefficient in structural strength. I have already shown they are composed of three parts, represented by five pieces, namely, two bars for an angle iron frame, a floor plate, and two bars for an angle iron reverse frame. All have to be furnaced, then bent when hot, and beveled. When cold they have to be set to exact line on body board, then spread out to be bolted together, and finally rivetted; each piece having thus about five operations to go through, entailing the employment of a great many men, and a great waste of time, for instance, the waiting about 20 minutes by six men, five times each frame, for the angle irons and plate to heat, and where there is much bevel on a bar an extra heat has to be given each bar in addition. How different with longitudinal framing! and yet more so with the vessel I have designed and have yet to describe.

In the longitudinally framed ships, firstly, the iron is being used in the structure so as to give out the greatest strength, and, secondly, the cost is reduced to near a minimum.

The curves in the direction of a longitudinal frame are very easy, so that the frame can be bent in its cold state, and can be formed of but one section of iron, in place of the number of sections as in present practice, thus saving the vertical sides of two angle irons, or a whole angle iron, and two rows of rivets across floors, and one up the side at each transverse frame in ship. The longitudinal frame can be bent cold, as stated, and twisted so as to bring the frame at right angles to the shell all fore and aft, thus avoiding destroying the iron by beveling. This can be done by a machine I have invented and

patented for the purpose. The machine will record on a dial the exact amount of twist put in the bar, so by adjusting the dial to the twist required, the bar can travel through the machine and finish with the necessary twist given it. The bending is done with as great simplicity, so that with one set of men I could bend and twist the same length of longitudinal frame that there is in a transverse frame, thus finishing the part, ready for going to its berth, in less time than it takes to heat one bar of the outer angle iron alone of an ordinary ship's frame; or, in other words, one set of men could bend and twist the whole of a ship's framing on the longitudinal system quicker than the outer angle irons for the framing of a transversely framed ship could be bent, without mentioning the after-setting, also bending and setting reverse frames, the bending floor-plates, bolting all together, and riveting up, which compares as extra, waste and inefficiency.

We here save material, save labor, save time. Another advantage of longitudinal framing is that the longitudinal keelsons and wash plates employed in the transversely framed ship are dispensed with, thus saving material and labor, the frames themselves doing the work of keelsons. It is true transverse strength has to be given, but this is only requisite amidships, and does not put in as much iron as we take out. Longitudinal framing gives a *stronger bow to the ship*, as the frames come closer together the nearer you approach the ends, and finally unite with a breasthook, which is a point of structural strength requisite in American ships, for the winter's experience teaches the difficulty of winter navigation. While longitudinal framing protects and strengthens the bow, it also greatly assists the stern, by giving an increased lateral strength to resist the vibration caused by the screw propeller. We may summarize the structural advantages of longitudinal framing as increased strength of bow and stern, increased longitudinal strength, increased strength of frame by twisting instead of beveling (allowing the frame thus always to sit at right angles to the shell plating), a better distribution of the strength given by bulkheads, support and connection given the shell by each frame crossing the butts (the weakest place), the prevention to wash of bilge water across the bottom as the ship rolls, with the consequent likelihood of rivet-heads and plating being worn down by debris.

The economic advantages lie in the frames being of one section of iron, of their being bent and twisted cold and by machinery, the whole labor being done at one handling; of there being no riveting to do beyond the connection of the butts, and no yard space required

to spread the frames on ground, as they go direct from machine to their berths—the whole resulting in a saving of time, material and workmanship.

The degrees of comparison we are familiar with as three in number, and whatever opinion you may so far have formed of iron ship construction, I consider that the positive and comparative only have been touched. Positively, the present ship is transversely framed. Comparatively, the longitudinally framed ship is much superior to the transversely framed ship, being stronger and cheaper. But the superlative ship must be *welded*, thus saving the punching away of material, and keeping up the original strength of material as absolute strength of structure all throughout.

The process of uniting iron by means of welding it together traces back to about pre-historic times, so it it is out of reach of man to claim originality in discovery of principle here traceable; but originality is claimed by me for the discovery of means to apply the principle of welding to ships, for I now can weld up a ship in entirety by *machinery*.

Boilers have been welded successfully, but at great trouble and expense, through inappropriate methods being adopted. My late grandfather, Mr. Timothy Hackworth, the inventor of blast-pipe and builder of first locomotive that ever beat horses, had the honor of constructing the first welded boiler at his establishment in 1849, in which year the boiler of passenger engine "Sanspareil" was welded.

Tubes are being welded every day in this city, and at the yard of John Roach & Co. boiler flues of large diameter are welded, which shows the bent of present mechanical desires and necessities. Suggestions that may lead to revolutionizing changes in the iron mechanical structures of the world, are thus to be daily gained, and when once possessed, the impelling force of duty to yourself, your neighbor, duty to the State, should constrain the individual to act his part with earnestness. It would be superfluous and a supererogation to attempt to show a mechanical man that a weld is superior to a rivetted joint, and a ship owner would tell me that it was unnecessary to prove to him that a whole plate was stronger than two plates indifferently connected. The mode of forming a weld is matter of considerable importance, and I here enter a protest against the main strength and stupidity method of battering all the nature out of the material by a succession of blows. Hydraulic welding is a step in the right direction, for we here get weight or pressure without a blow, and can form

a perfect weld. The method I introduce must be explained further on, as I must now call your attention to my combined shell and frame, welded ship.

The interest in iron ship building, and absolute necessity for something to be done in reducing its cost, has caused me to give my closest attention and best thoughts to this subject, which I have been familiar with all my life and have solely practiced since my business career commenced. As soon as I had mastered the situation here, I turned my attention to longitudinal framing, as an improvement in iron ship construction, and have advanced by degrees with three points full in view, namely, structural strength, section of iron, and machinery instead of labor. Discarding transverse framing altogether, as a mechanical abortion, I took refuge on the longitudinally framed ship, and designed and patented a machine for bending and twisting the frames, as already alluded to; but I was still dissatisfied, as the method of fastening compelled the introduction of necessary yet useless weight. I allude to the requirement of packing iron, which is necessitated by the frame passing over the butt straps, so that between strap and strap there is an interstice equal to the length of plate, thickness of straps and breadth of frame, which must be filled in solid, or the frame must be joggled over the strap. The latter arrangement, however, gives too much labor; so the packing difficulty must otherwise be got over. Putting the straps outside suggested itself, but appearance must be kept up; besides, we should be adding resistance by an uneven surface. Then the suggestion of butting the edges of plating, and making the longitudinal frame act as straps was considered, but this gives too much riveting; besides it throws the frames wider apart than I desired; so the difficulty still presented itself. I thought over the matter by night and day, and finally settled it must be accomplished by *welding*, and quickly realized the other benefits embraced by this mode of fastening, but was as quickly enveloped in the darkness of practical difficulties surrounding its accomplishment. Were there not practical difficulties of an apparently overwhelming nature, welded ships would long ago have been a reality. The difficulties to contend with were, first, to get a welding heat on a ship; second, to discover a method of forming the weld; and, third, and perhaps the worst difficulty of all, was to prevent the stretching or buckling of plate, which is a practical difficulty that would make welding a failure were it not met; for, supposing two plates on a ship's side, bolted in position, with the requisite amount of scarphled lap'

the thickness here, of course, is greater than single thickness of plate; so when the weld is made, and the scarph drawn down to near ordinary thickness of material, the thickness has then changed shape, and the area is made up by more surface being given it, which increased surface results in a buckle, and before the welding has proceeded far along the edge, the buckling and twisting will have increased until the two plates are imitating a pair of scissors, by either opening apart or closing over each other, thus foiling your attempt and wearing you out with everlasting aggravation and failure.

This has been the stopping point together with the mode of making the weld, and I here claim originality of device, for I have dispensed with hammering or forming the weld by labor that takes the nature out of the material, *and invented a machine to do the work scientifically.* I have also overcome the buckling difficulty, by *designing an entirely novel and original ship.* The novelty and originality of my vessel lies in the *plating and frame being formed of one and the same piece of iron.* This is accomplished by using for the shell iron with a flange at each side, such as is known as Channel iron. One flange accordingly comes against the other, thus bringing together two narrow strips of iron, which have but to be brought to a welding heat and the operation of a squeeze applied and the weld is complete. You will, in less time than it has taken me to utter this, have comprehended how I dispel the buckling difficulty, for the extra thickness before the weld is made has plenty of room to spread out in surface or breadth of flange; for, owing to the flange being narrow, and the pressure covering its whole breadth, it gives on the edge instead of buckling, as is unpreventable in a broad plate with a blow or a pressure coming upon a narrow strip of it.

My method of forming the weld is of the simplest description. It is done by a blow-pipe fire preceding a pair of rollers, as illustrated by drawing. The fire I propose to make about two feet long, and convey the blast to it by india-rubber tubes connected to a main blast box, running, under ground, the full length of building slip. I enter one blast at the fore part of fire, so as to heat up the iron; then, at after part of fire, I throw a blow-pipe flame on to the iron—which brings it to a welding heat. That is no sooner arrived at than I travel the rollers over the place, thus squeezing the material together and forming a perfect weld without hurting the material in the least.

My patent welding machine is composed of a piece of flanged plate iron, acting as a frame, at the lower part of which are a couple of

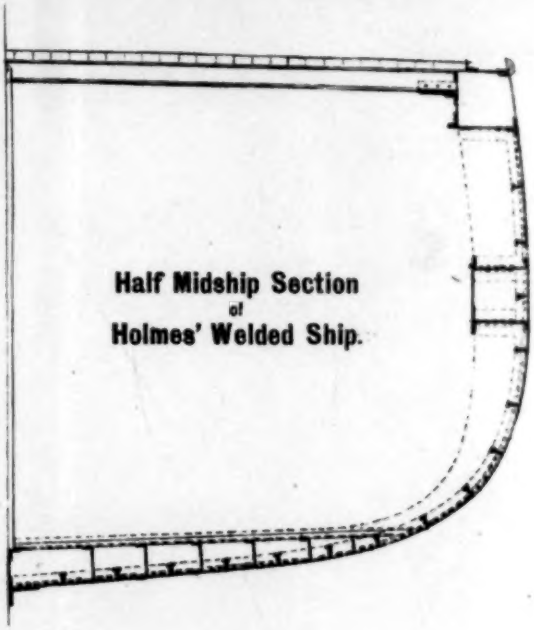
metal blocks, riveted on, through which the spindle of lower roller passes and becomes a fixture. At the upper part of frame are two other metal blocks, through which the upper spindle passes. These blocks are confined by guides which give latitude to travel with a vertical motion, which is regulated by two screws, thus enabling the man in charge to fix the rolls at their requisite pitch to perform the work. The fire-box is connected to the back of frame by a hinge, which enables the fire to be swung away from the ship's side. There is also a slide attached, so that the fire-box, if necessary, can be pushed forward while still attached to frame of machine. The whole affair—machine and fire—is travelled forward on the welding flange by means of a ratchet, or handspike pulley (to save weight, fitted on the lower spindle), as rapidly as the welding heat is arrived at. That the fire may have full play upon the inside of flanges, I propose having the iron rolled at the mill to an acute angle instead of right angle, thus leaving the two surfaces open for the force of fire to play upon. The weight of machine is counteracted by a balance-weight on outside of ship, which is attached to machine by a chain passing over a pulley travelling on top of flanged plate, so that no unnecessary weight is brought on the heated flange. As soon as the right pitch of rollers is ascertained, I clamp them by a screw close to the rollers, so there may not be any spring to the spindles, and the iron be given a uniform thickness.

As a further remark, I must add that the method described is simple and practical, and is based upon the following propositions being satisfactorily replied to: Firstly. Can iron be brought to a welding heat? To which the reply is, Yes, it can, and is every day; thus practice being practical proof. Secondly. Is it necessary that the fire should be on the ground as a fixture? Certainly not; heat is not dependent upon such considerations. Thirdly. Can iron be welded? Yes, it can; every day's experience teaches the truth of it. Fourthly. Is a blow necessary to form a weld? No, it is not; weight or pressure is the requisite, whether as a blow or a squeeze, preference being given to the latter, as the former has a tendency to crystallize the iron and make it brittle. These propositions being satisfactorily settled leave the ground clear, and let those who have the courage and ability apply the principles to the furtherance of the mechanics of iron ship building.

The detail comparison of longitudinal strength between welded ships and transversely framed ships of 500 tons is as follows:

S. HOLMES

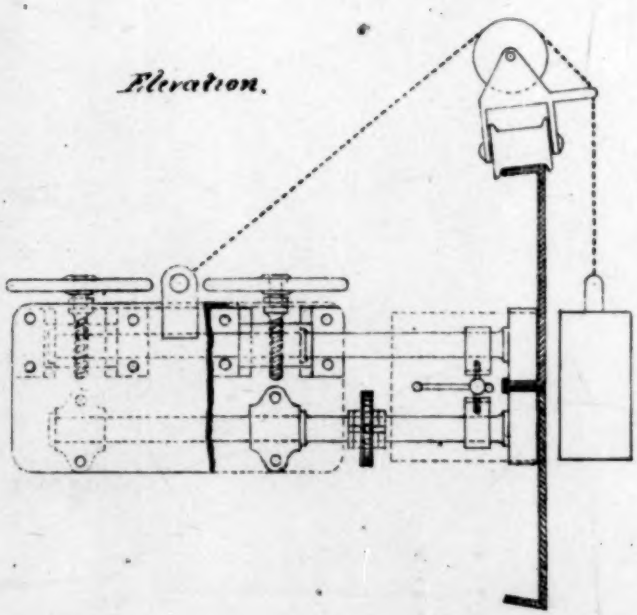
IMPROVEMENTS IN SHIP BUILDING.



Half Midship Section of Holmes' Welded Ship.

Holmes' Welding Machine.

Elevation.



Plan.

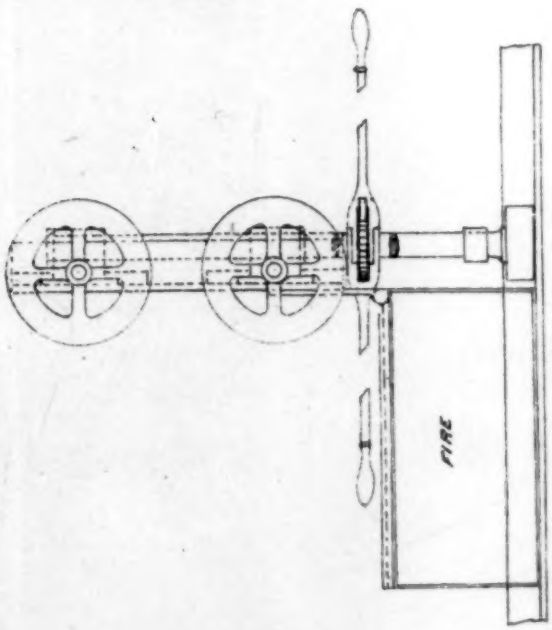


PHOTO LITH. BY A. DICKES, 125 SOUTH FOURTH ST. PHILA.

Transversely Framed Ship.		*Welded Ship.*	
Shell	374·00 sq. in.	Shell	346 00 sq. in.
Keelsons	51·00 "	Frames	102 00 "
Stringers and their Angles	86·00 "	Floors	74·00 "
Keel	16·75 "	Girders	187·00 "
		Centre Keelsons	20·00 "
		Keel Flange-plate	18·00 "
	527·75 sq. in.		747·00 sq. in.

Comparative strength, 747·00 : 527·75, or 41 per cent. in favor of Welded Ship.

As I only propose carrying these longitudinal floors along the straight parts of bottom, I think in most cases (where light draft is not a necessity) it is desirable and an improvement that they be outside the ship instead of inside, thus *effectually protecting* the bottom, greatly steadying the ship, and vastly increasing the capacity, while they add little extra resistance, for it is chiefly a resistance of friction. That the increased frictional resistance is small, I consider fully proved by the fact that 30 or 40 feet can be added to a ship's midship body, yet her original power will drive her at about her original speed. To show you the restriction upon rolling these outside floors would have, I will quote experiments made upon a model with bilge keels by W. J. Froude. The model was first heeled over and set oscillating without bilge keels; secondly, with a single keel on each side, 21 in. deep; thirdly, with a single keel each side, 36 in. deep; fourthly, with two keels on each side, 36 in. deep; and, fifthly, with a single keel on each side, 6 feet deep. The results were as follows:

	Number of double rolls before model was practically at rest.	Period of double roll (second).
No. 1 No bilge keels,	31½	1·77
" 2 Single 21-inch bilge keel each side,	12½	1·9
" 3 " 36 " " "	8	1·9
" 4 Two 36 " " "	5¾	1·92
" 5 Single 72 " " "	4	1·99

These results demonstrate in favor of outside keels to reduce rolling, for the number of rolls decrease 87 per cent., while the period of double roll increases 12 per cent. Such would be the effect upon my ship, and as rolling strains the ship transversely, this greatly reduces the necessity for transverse strength.

This I have shown can be done, and now let those who are equally interested with myself put the shoulder to the wheel, and American iron ships will lead the world.

Before dealing with the matter of cost I shall further describe the ship which in other particulars differs with anything yet constructed. The frame, it will be seen, takes the course of a longitudinal frame, as advocated, and it is worthy of remark that the assistant strength the shell derives from it is at the exactly requisite spot, namely, the point of connection between one flanged plate and the next. The butts I also propose to make equally strong with the seam, by turning up or flanging in the end and welding, as I do the seam, which gives me transverse stiffening at each butt. The superior structural strength of the shell and framing is that the whole is one solid piece of iron, without a hole, and accordingly of the original strength of material, which, in comparison with a double rivetted ship (the present first-class ship), as I have already shown, is 30 per cent. stronger (the superiority of solid plate over rivetting), which result is proved by experiment. Again: through being longitudinal framed, she gains 41 per cent. without deducting punchings in transversely-framed ships in comparison of longitudinal strength as seen in detail, making a total of 71 per cent. increased strength over the present first-class ship.

The extra strength which I give the bottom is obtained by means of large angle irons welded between the flanges of frames having the wide flanges vertical, and acting as longitudinal floor plates or keelsons. Or, I believe a better way would be to use channel iron the same depth, and place it at the *centre of each plate*, so that the bottom would be double stayed—stayed by vertical flange of frame, and by this channel iron, or T iron—floor at a distance of nine inches apart, centre and centre. From the centre of ship out to the bilge I reduce these floors in depth by a fair taper.

I have already shown the connection between the side of a ship and the deck is the weakest place in iron ship construction, and as the present mode of putting in beams does little to alleviate the trouble, I introduce a box girder, which is one of the strongest forms to arrange iron, as it gives out strength longitudinally and transversely, precisely what is required at this particular spot. Accordingly, inway of decks, especially the upper deck, this girder takes its place and continues all fore and aft, between the ends of beams and sides of vessel. The beams are attached, as shown in sketch, to the inner side of girders, and thus have their strength diffused along the side of ship and not confined locally, as at present, and, as already shown. From this girder at under side to side of ship, I fit plate knees at stated

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intervals, so as to spread the strength of girder as much as possible, and when a girder is fitted at tween decks, I spread the strength by knees alternately at upper and under side. On the top of girder I fit a broad stringer plate, as in present practice, which gives still further attachment to the beam. My whole object is, as nearly as possible, to follow the practice of a successful general, and throw the heaviest metal at the weakest spot, and thus relieve places that can take care of themselves of superfluous strengthening. For instance, the bilges and the connections of sides and deck are so closely associated that a weakness at one point reflects upon the other, accordingly, by strengthening the attachment of sides and deck, I can dispense with much transverse strength at the bilges, as the curves in plates there give superior strength to this part, and the vessel is guarded sufficiently against the strains tending to collapse her like a parallel rule. The fastening of bulkheads I have already explained in the longitudinally framed ship; they are to be carried by knees and made tight as recorded.

Transverse strength I give liberally to the flat of bottom and flat of side, as these are the places tempted to buckle by pressure or stress. These transverse stiffeners I propose to run entirely round the vessel's section at midships; but forward and aft of this I shall confine them to the flat surfaces. On the side, I reduce the strengthening in proportion to shape of a buttock line, that is, deep vertical side, stiffeners amidships at stated intervals, shortening to nothing at ends. The bottom I propose to strengthen similarly, reducing the transverse fastenings in the shape of a water-line. All parts of the ship that are curved will take care of themselves, as the curve in the shell plates is a better diffused strength than can be given a flat plate by extra stiffening. The mode of securing this transverse strengthening is a point I carefully provided for, so that I avoid the evils now witnessed by the transverse frame. I connect my material to ship's skin through surface plates of considerable width, so that any holing that has to be done is not done at a material loss of sectional area. The beams I spread further apart, owing to the introduction of box girder, and I propose to pillar each beam. I adopt the solid stem and sternpost, but certainly discard the bar keel. Having thus given you a brief description of the construction of my proposed welded ship, and having shown the superior strength she possesses over anything ever yet built, I am pleased now to show up a clear record of reduced cost in comparison with any vessel yet constructed.

Many of you will doubtless have preceded me in arriving at this point, and could yourselves show with clearness the great saving I effect in cost, but others there may be who regard all talk of reducing the weight of material and keeping the strength of vessel up, or rather over what it was by 71 per cent., as moonshine. To these, if there are any, I would address a few earnest words. First, a great gain at a saving assuredly is the case; and, secondly, to make it clear, I call particular attention to the fact that the material discarded is principally material that is only requisite for the style of fastenings adopted. Discard rivetting and you discard quantities of iron, such as butt straps, packing, laps of plating, rivets, &c., &c., which are of no value to the structure, beyond being essential to rivetting. The items I shall now proceed to enumerate are positively an out and out saving, and though it is frequently said, oh! that is an estimate, we will divide it by two, you must understand these are hard and fast items there is no gainsaying.

Saving in Material in a vessel of 500 *tons.*

Butt Straps,	12 tons.
Packing,	6 "
Bulkhead Liners,	2 "
Plate Landings,	12 "
Rivets,	17 "
Reverse Frames,	13 "
Longitudinal Keelsons,	19 "
Beams,	3 "
	84 tons.
Deduct additional weight for transverse strength and longitudinal girder,	24 "
	60 tons =

16·3 per cent. on the total weight in favor of the welded ship. The punchings I account for by pairing with the scrap, as they are more than balanced by lack of scrap the ordinary shell plating is necessitated to bear. The extra cost of proposed form of shell plating over ordinary shell plating, equal to one cent per pound, or 5·3 per cent., owing to the iron used being flange quality, instead of common, as now used. I have already explained I reduce in weight, thus avoiding the increased cost, while I preserve the strength through superior quality of iron.

Saving in Cost of Labor:

Transverse Frames, Reverse Bars, Floors,	20·0	per cent.
Drilling,	2·8	" "
Caulking and Chipping,	10·3	" "
Straps and Packing,	3·9	" "
Countersinking,	1·5	" "
Saving on total labor.	38·5	" "
Deduct work on extra Transverse Fastening and Box Girder,	3·2	" "
	35·3	" "

in favor of welded ship.

The saving thus stands 16·3 per cent. on iron and 35·3 per cent. on labor in favor of welded ship, and gain in strength of 71 per cent. We must also take account of 10½ per cent. saving of coal, as all the work is done with cold material, thus saving fuel required for furnace. The fuel for welding will balance the fuel for rivetting where the same fuel is used, but more suitable fuel is designed. The work on the frames, reverse bars and floors of a transversely-framed ship is entirely saved, for you will have observed I have the frame and shell plate in one section of iron, so that the work required to bend and twist the plating is bending and twisting the frame at the same time. I do all by special machinery, giving the required twist and set to the workmen from the mould loft floor. The labor on keelsons I do not deduct, as it balances the work on transverse strength, which I add. I also set the labor of welding against the labor of rivetting; but as the rows of rivets in seams, butts and frames exceed the seams to be welded, I consider my estimate more than on the safe side. There is one point I must yet call attention to, and that is the fact of the flanged plates used for plating being all of parallel breadths, and the ship herself having a greater girth at midship section than at the ends. The mode of procedure I propose, is to work from the deck and from the keel, and make up the difference of girth by stealing strakes, or a broad taper flanged plate at bilge, the flanging of which I do by machinery.

This method is practically illustrated by the model before you, which is made to scale, built of copper with sections of material as proposed. The parallel plates have this advantage, that they can be kept in stock, so the ordering of iron is greatly simplified. At pre-

sent each plate is of different dimensions, that is, different taper, and accordingly has to be separately enumerated; but with the alteration the expression of 500 tons, or 1,000 tons of channel iron, a certain length, breadth and thickness, will bring to the yard the material required. The quality of the iron deserves more than a passing notice, and in this particular my ship will far surpass anything yet produced, as she is constructed of iron, flangeable in quality, and bearing an increased breaking strain to that formed by the common or boat iron now in general use. It is, perhaps, worthy of observation that the tendency of ship-building is towards steel, with view to economy—that is, to carry in cargo what is dispensed with in weight of hull—as soon as the manufacturers produce the material dependence can be placed upon.

This principle of economy is embraced by me and embodied in the vessel I have delineated. She is of superior iron, which has increased tenacity; accordingly I can reduce the weight, retain the strength and carry in cargo the reduction. Apart from this particular saving in shell, my ship of 500 tons will carry 60 tons more than any other vessel afloat at the same displacement and draft as already shown in detail. A summary of advantages I claim for my welded ship is as follows:

Increased strength, ...	71 per cent.
Increased safety owing to above extra strength, bottom protection, as described.	
Saving (material)	16·3 "
Saving (labor)	35·3 "
Total mean saving on these items . .	20·92 "
Increased capacity owing to floors being outside.	
Increased dead weight (cargo) carrying ability 10 per cent. Less time in building about 20 per cent.	

With the growth of the iron trade, we expect quicker supplies of iron, and these at a reduced cost. The breadth of iron I propose to use is 18 inches, which will give support to the plate the same as at present, for though the frames are now generally 21 inches apart, there is a 3-inch flange, which gives some support. At my last visit to the Phœnix Iron Works, I brought my ideas before the managers there, and they told me, though they do not now roll channel iron over 12 inches wide, yet they will, if required, put down rolls. In fact, they wish to help along iron ship-building, and are extending their premises vastly, that every facility may be possessed for turning out iron cheaply.

To give you some idea of what they are doing, and accordingly what we may expect from them, at present they have a new mill in hand, 900 feet long by 296 feet wide, at a cost of one million dollars. This will be erected with every known labor-saving convenience.

Some particulars of the iron trade are not out of place here. The manufacture of wrought and pig iron has doubled itself in ten years; last year added 20 per cent. Within eighteen months the manufacture of Bessemer steel will have doubled. 95,000 tons is now manufactured, and within two years 125,000 tons will be added. This great interest is spreading and spreading, and those who strive to oppose it or set the forest against the mine, will find they are striving against material that will crush them. Though it has taken iron ten years to double, the last year shows by its proportion five years will now do it; but as the percentage increases each year, it will more likely double in three years.

I should like to touch upon shipyard plant, but time won't allow. However, I must add, I reduce the expense of a yard materially by dispensing with much heavy machinery and, at present, necessary tools, yet do all the work by machinery. I also hoped to be able to treat upon the localities for the yards, but must curtail.

My theme has been iron ships, and for the reason my honest convictions embrace iron as the best material, but I rejoice to know ships are wanted. Tonnage is scarce, and those that can build the best, quickest and cheapest will come to the front. I have no fear as to who will win; perhaps it matters little. What I request is that we each have the same advantages allowed. Competition has and will quicken our wits to the benefit of the country, and what has been done in other branches of industry will be done in ship-building.

I have given prominence to reduction in labor, but let me not be misunderstood here. It is not my desire or presumption to attempt to pull down the bulwarks of the country or sully a Scripture truth which stands forth with grand prominence as an article of the American's creed, declaring in letters bright as the stars in the national flag, "The laborer is worthy of his hire." Let us continue an elevated remuneration to labor, and the brain will save the body. Expensive labor is not a matter to be groaned over; not a matter to be regretted, but a matter to be overcome. How do we progress? Is it by never encountering difficulty? No! Is it by Faith, Hope and Charity, as our pastors direct us to gain heaven? No! but these may be component parts of our system. Is it by scratching away with pencil or

chalk, when a flash of thought will do the work? No! Do we progress by ease and indolence? No, no! this is rottenness, worse than the contents of a whited sepulchre. It is by hard work, by new devices, by head, and not merely hand. Our superior remuneration is our great advantage, and very little time—mark my words, very little time—will declare it so that all will understand the mystery of liberal wages and cheap mechanism.

It has thus been my pleasant duty to foreshadow what can be done to facilitate a return of progress and prosperity to American shipping, and this I do by a method I believe to be the only true and practical one there is. Bounties are dangerous; monopolies restrict private enterprise; subsidies cannot be depended upon. So we must go to the vessel herself, where much can be done. I find it cause of congratulation that these changes fall to be made in America. Here precedent does not, must not, sway. The trammels of old age do not encumber the mind as elsewhere. Here we are not "cribbed, cabined or confined" by any conservative institution to the utter smothering of what is good in the new ideas of genius or common sense. Let us act, then, at once, that we may perfect ourselves before others begin to stir; and, if we move with energy, I look forward to the time when not only the American model but the American structure will be copied by the world.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at the rooms in New York, March 19, 1873.

Joseph Whitney, C. E., of Cambridge, Mass., presented the subject of "Leakages in Water Pipes," illustrated by specimens of defective water pipes from the Cambridge water works.

He desired to make a simple statement of his own operations and experiments. The great and growing increase in the consumption of water, is a matter of the first importance in the management of water works. Scarcely a report relating to water works is issued which does not refer to it, and, as something quite unaccountable, still no systematic effort is made to ascertain its cause.

Some years since his attention was called to the subject in Cambridge, where, for three years preceding, the water pressure had been growing less, thus causing much inconvenience and insecurity in case of fire. This was ascribed to the great number of users from one

main, an eight inch pipe. In a particular house the water scarcely rose to the second story, at night or day. After inquiry, a series of observations were made with syphon pipe and pressure gauge, to determine the cause. These were made in the morning, when the consumption was nearly nothing, and in one case, by shutting off certain sections from the main, say a four or six inch pipe, a large leak was revealed where the pipe, laid in a street filled with oyster shells, had parted. In another case, when the gate was closed, the water in the syphon at once rose sixteen feet—equal to about two stories of an ordinary house—the pipe about 600 feet long and laid upon a mach, was examined, and the leak found in a joint where the two parts had been entirely separated by a settlement of one section. These and other leaks, detected similarly, were closed, and thus, without any increase of size in the main, an additional head was secured of 35 feet, which gave a full supply to each house in that locality.

Observations were afterwards made upon the water in the reservoir in the night time, which showed still a leakage. By continued experiments upon the pipes throughout the city, nearly 200 leaks, of from 1000 to 2000 gallons each per hour, were found. The necessary repairs were made, and thereby the average daily consumption per head was reduced from 85 to 35 gallons, which is not more than one half that in most cities.

Leakage of this character may exist a long time without being known; thus, it may start when the water is first let on, and teh water find a passage through some blind channel into the sewer. It will not be seen at the surface unless thus upward and outward is the easiest course.

It is quite probable that this subject concerns other cities than Cambridge, and furnishes a satisfactory reason for the great increase in the consumption of water, and the corresponding growing demand for supply, which more or less embarrasses public authorities.

It is said that in the city of New York, the consumption is about one hundred million gallons per deim; if so, he was sure at least fifty million were wasted through unrecognized leaks into the sewers and surrounding rivers. In Boston, more than seventeen millions of gallons are supplied, where eight millions should suffice.

It is a fair presumption that one half these great amounts, being but waste, and its corresponding cost in the construction and operation of water works, may be saved. Surely, examination, complete

and exhaustive, should be made, to determine whether this is presumption or fact.

Thomas F. Rowland, M. E., of Greenpoint, N. Y., presented a paper on the "Adaptation of Mechanical Power to the Work of Charging and Discharging Gas Retorts," illustrated by a large working model of machinery for the purpose; by which it is proposed to take the coal from a pocket outside of the retort house, size, mix, transport and deposit it in proper quantities in the retorts, and afterwards discharge therefrom the resulting coke into the coke-barrows.

The apparatus consists, first, of an iron car, which traverses the retort house in front of a bench, upon a railroad of twelve feet gauge, and carries the mechanism for charging and discharging; and, second, a series of buckets which, suspended from an overhead or "pendant railway," conveys coal to the charging apparatus.

The iron car, about fourteen feet square, is propelled by an engine and boiler placed upon it, which also drive the machinery carried. Midway on the car the meter is located, which receives the coal from the buckets and deposits it in the charger.

The meter is a horizontal cylinder divided longitudinally into three compartments or cavities, such that each will contain enough coal for one retort. It revolves intermittently at the base of a hopper or "coal pocket," which receives the coal from the buckets, each cavity therein being in turn filled with coal and emptied by discharge into shutes, severally in communication with the three scoops of the charger. These shutes are placed one above the other, and as the meter revolves, are automatically opened and closed, so that the coal is discharged into each in succession. The edge of the meter cavities and of the throat of the "coal pocket" are armed with hard, sharp, steel blades, to cut or crush fragments of coal which, lodging between the surfaces, otherwise might clog the machine.

The "charger" is a carriage traversing the top of the car, transversely; its three scoops are placed one above the other at distances corresponding to the vertical measure between the retorts; they are D-shaped, like the retorts, and have moveable bottoms. When the scoops are filled, by a transverse movement of the carriage, they are thrust forward into the retorts; the motion being reversed, the bottoms, and then the scoops, are withdrawn, thereby the coal is deposited evenly over the retort, and the scoops made ready for another charge.

The "discharger" is a carriage similar to the "charger." The

two are placed at opposite ends of the car, and the meter between them. By an automatic device, three hoes or rakes are simultaneously thrust into three retorts, dropped until they rest on the retort bottoms, and then withdrawn, whereby the coke is removed and discharged on to the retort-house floor, or into coke barrows.

One tier of retorts may be charged and the adjacent one discharged at the same time, and in a very brief time.

The "pendent railway" consists of two single parallel rails, ten feet apart, suspended from the retort-house roof, over the railroad before mentioned, and connected at the ends by semi-circular rails, thus together forming an endless line, from which is suspended a series of coal buckets, attached to a flexible steel belt, by which they are separated, at uniform distances apart. The belt passes around horizontal drums, ten feet in diameter, and placed one at each end of and below the line, their vertical shafts being in the centre of the curved rails. One of these drums is an idler—the other, that at the receiving end, is in a tower outside of the retort-house. In its periphery are two openings, diametrically opposite, which, by two inclined shutes, are connected with a fixed cylindrical hopper or reservoir for coal above. The buckets are vertical cylinders with one half of the upper part cut away, so that when they are in contact with the drums, their acial planes coincide with the periphery. The space between the buckets on the belt is equal to one half the circumference of the drums.

When this apparatus is in motion, the buckets pass along the "pendent" railway; their openings are brought successively in contact with the openings of the drums, so that the coal conveyed by the inclined shutes from the reservoir, drops through them—the quantity being regulated by valves in the shutes, worked automatically.

The buckets have hinged bottoms to drop downward, and are opened when passing over the "coal pocket" on the car, at the will of the operator, by releasing a catch; they are mechanically closed just before reaching the drum, where they are filled.

The coal in the yard, after passing between sizing and mixing rolls, is lifted to the reservoir over the drum by elevators, similar to those used at Messrs. Hecker's flouring mills in New York.

The several parts of this apparatus can be worked independently, and thereby accommodated to the varying demands likely to be made upon it.

Chemistry, Physics, Technology, etc.

THE REDUCTION OF AURIFEROUS PYRITES BY DESULPHURIZATION AND AMALGAMATION.

Facts and Figures.

By Dr. Ira M. Phelps.

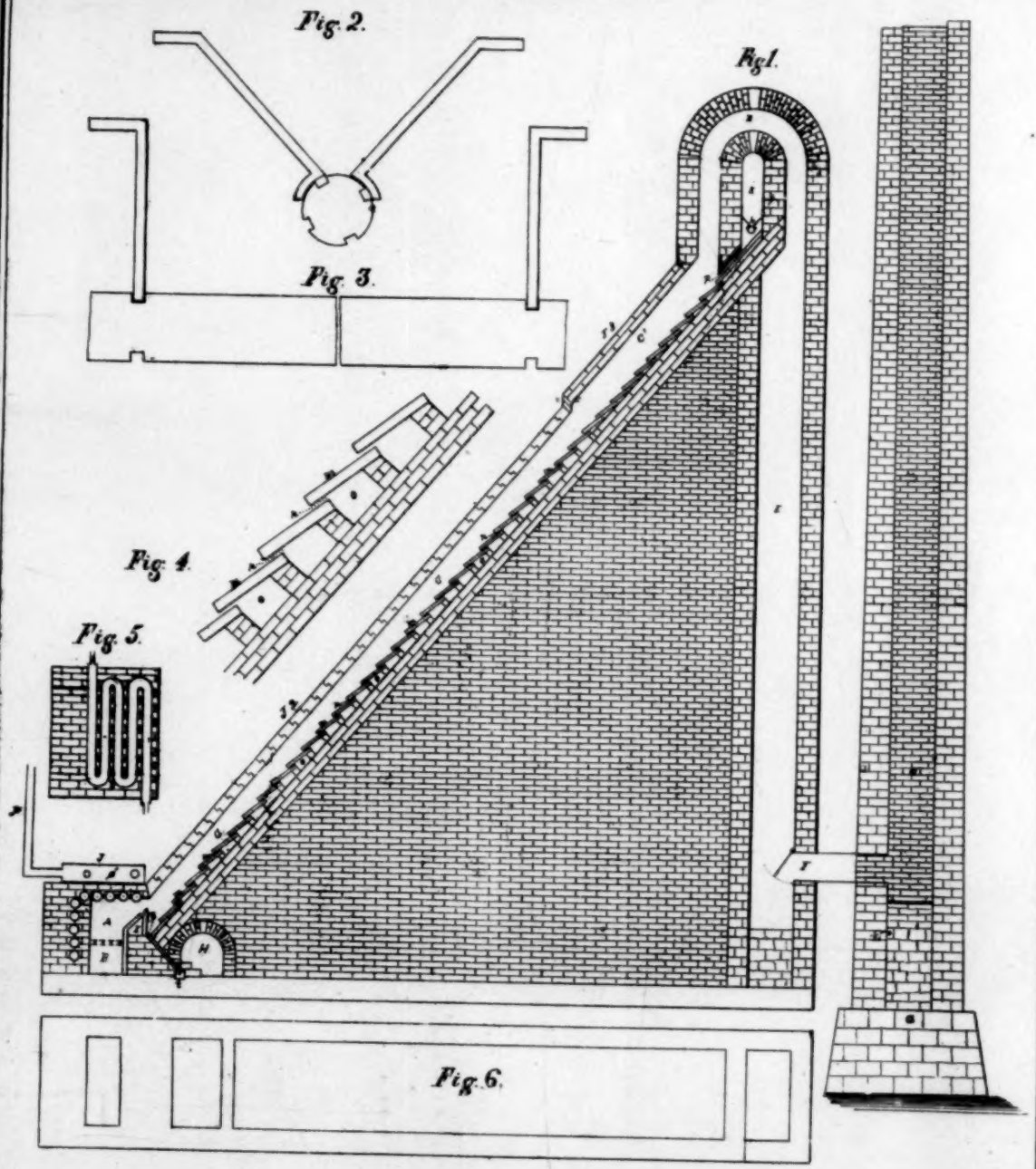
The reduction of gold-bearing iron pyrites by desulphurization and the abstraction of its precious metal or metals by amalgamation is an object of the highest metallurgical importance, as well as scientific interest.

The peculiar attractions of this process, and its promised superiority over all others, consist in its evident simplicity and cheapness, for by this method the sulphur contained in the ore furnishes a large portion of the fuel; it being compelled, in a great measure, to consume itself; and, secondly, in the inexpensive yet efficient chemicals made use of. Oxygen and mercury, the former obtained from the atmosphere without money and without price, and the latter secured against excessive loss by properly constructed amalgamators, are the only chemicals needed, except that furnished by the ore itself. Besides, it is a little gratifying to be able to seize upon this most troublesome element, sulphur (the cause of all the failures and disappointments), and compel it to do duty, not only in accomplishing its own destruction, but in effecting the release of the golden treasure it has so long and persistently guarded.

That a thorough desulphurization of the ore is a necessary prelude to amalgamation is a conceded fact, but right here has been and is the great difficulty, and so many failures have been made in trying to accomplish it, on a large scale, that not a few of the unsuccessful experimenters declare it an impossibility.

That the cause of all the failures has been *an insufficient supply of oxygen* can, we think, be proven to a mathematical demonstration; the enormous bulk of air necessary to supply it having never been even approximately estimated or conceived. But in addition to this there are three other conditions, to secure and maintain which is of vital importance, making four in all, viz.: *First.* A supply of oxygen sufficient to meet all the demands of oxidation. *Second.* A proper and timely regulation of the heat. *Third.* The constant agitation of the ore. *Fourth.* Sufficient time to perfect the chemical

PLATE. I.



Dr. Phelps' Oxidising Furnace,

THE

changes involved. To enable the reader to comprehend the difficulties imposed by the first condition mentioned above, we will make an estimate of the quantity of air necessary to desulphurize twenty-four tons of pyrites daily.

Sulphur, as every chemist knows, when burned, consumes an amount of oxygen equal to its own weight; hence, if we can ascertain the number of pounds of sulphur contained in a ton of ore, we at the same time determine the quantity of oxygen necessary to effect its combustion.

This, of course, cannot be done with absolute correctness, for the reason that the ores, as delivered at the mills, are never chemically pure, but a sufficient approximation to the truth can be obtained to answer the purpose of illustration.

Iron pyrites, the most abundant and the richest, as well as the most refractory gold-bearing ore of the Rocky Mountain districts, is a bisulphide, consisting of two equivalents of sulphur and one of iron. Reduced to a per cent., it contains $53\frac{3}{10}$ of the former and $46\frac{7}{10}$ of the latter. But, as just remarked, this ore, as delivered at the mills ready for reduction, is never pure, but is generally combined with other sulphides, such as that of copper, zinc, lead, arsenic or antimony, each of which contains a less proportion of sulphur than the iron. In addition to these it is frequently mixed with quartz and other gangues, containing little or no sulphur in their composition. Let us assume then, that the ore, ready for the metallurgist, contains twenty-five per cent., or 500 pounds of sulphur to the ton. Now if it be necessary to burn, *i e.*, *oxidize* this entire quantity, it follows that 500 pounds of oxygen will be required for the purpose; but, fortunately, such is not the case. One equivalent of the sulphur may be expelled by the action of heat alone, and without the aid of oxygen—a fact daily demonstrated in the process of obtaining the sulphur of commerce; a large portion of which is taken from non-auriferous pyrites, the identical bisulphide so richly impregnated with gold in many sections of the United States. In the process just alluded to, the air is carefully excluded from the furnace, in order to prevent the formation of sulphurous acid gas, but only one-half of the sulphur is driven off, and any amount of roasting, with the air excluded, fails to dislodge the remaining portion.

So in roasting auriferous pyrites, preparatory to amalgamation, it is found an easy matter to drive off fifty per cent. or more of the sulphur; but ore, only half desulphurized, is nearly as tenacious of its gold as the raw.

The fact appears to be that while one equivalent of the sulphur is easily expelled, the other is held in such close chemical combination with the iron, that heat alone, however intense and long continued, is insufficient to overcome the affinity, and oxygen must be introduced, in quantity at least equal to the weight of sulphur, in order to accomplish what the heat has failed to perform.

We have already supposed a ton of ore to contain 500 pounds of sulphur, and allowing that one-half may be driven off by heat alone, there will still remain 250 pounds in intimate combination with the iron, requiring 250 pounds of oxygen or 1,250 pounds of air for its combustion. A pound of air, at the level of the sea (under certain standard conditions of temperature and dryness), measures 13·29 cubic feet; but at the altitude of most mines, in the Rocky Mountain districts, a pound will measure at least fifteen cubic feet. On this hypothesis, 1,250 pounds will measure 18,750 feet, and this may be set down as the quantity required to burn out the sulphur in one ton of ore. But this is not the only demand made for oxygen, for the iron, as previously explained, must be thoroughly oxidized in order to be thoroughly desulphurized.

As the proportion of iron is a little less than that of sulphur, let us assume that 490 pounds is the average quantity to a ton of ore, the conversion of which into a peroxide will require 210 pounds of oxygen or 1,050 pounds of air, measuring 15,750 cubic feet.

From these data we are able to make the following statements:

Air required to oxidize the sulphur,	. .	18,750 cubic feet.
Air required to oxidize the iron,	. .	15,750 " "
Total air required for one ton of ore,	. .	34,500 " "
Twenty-four tons will therefore require	.	828,000 " "

This, be it remembered, is upon the hypothesis that every pound of oxygen, contained in this quantity of air, is used—no allowance having been made for loss or waste. In *practice*, however, only a small portion of the oxygen can be secured during its transit through the furnace, and an additional quantity of air, sufficient to make up the loss, must be transmitted, or another "failure" will reward the efforts of the disappointed and baffled metallurgist. Any person watching the operation of roasting ore in any of the furnaces now in use, will be convinced that not *one-tenth* of the oxygen transmitted is secured and appropriated during its transit.

Now if it be true, as the above facts and figures prove, that *all* the oxygen contained in 828,000 cubic feet of air is required, it fol-

lows, if only one-tenth is secured, that ten times the above quantity, or 8,280,000 feet will be required to perfect the work.

In order to assist our minds to comprehend this vast quantity, we will make one more estimate. Let us imagine this number of cubic feet to be extended in a single straight line; and when we ascertain it would form a body of air twelve inches square, *and* 1,568 *miles in length*, the thing begins to loom up in its truly giant proportions!

It may be urged that the water contained in the ore furnishes a large portion of the oxygen, and hence a less quantity of air is required. But it must be remembered that the above estimate is based upon the hypothesis that all the sulphur burned is converted into a dioxide (sulphurous acid gas); whereas, if aqueous vapor be present, a portion of it will be converted into the trioxide (sulphuric acid), which contains fifty per cent. more oxygen than the former; hence, if the water's quota of oxygen is thus disposed of, the first two eqs. must be furnished by the air as in the above estimate.

Enormous as this quantity is, it is probably far short of what is really required by many furnaces now in use, owing to the fact that the one great and essential feature of economy in the use of air is entirely ignored in their construction. The prevailing practice is to 'save' one pound of oxygen and suffer ten, twenty or more to escape, and after much labor and vexation of spirit, to wonder why the operation proved a failure! A far greater wonder would it have been had it proved a success.

A person attempting to melt a ton of pig iron by using only *one bushel* of coal, would be considered a fool or a lunatic, yet men of sense have been trying, for years, to accomplish a similar absurdity, by burning a ton of sulphur with one or two hundred pounds of oxygen; whereas, nothing less than ton for ton can accomplish the work. In one respect, such experiments have been uniformly successful; they have proven, to a demonstration, how the thing cannot be done.

The second condition mentioned, viz., the proper and timely regulation of the heat, is all important. The great danger is the production of too intense a degree while a considerable portion of the sulphur yet remains, thereby causing a partial fusion or "slagging" of the ore. This is particularly liable to occur in those furnaces in which it is roasted in batches, and constant care and labor are required to heat the ore gradually, with constant stirring, in order to prevent the accident alluded to. This constant stirring (the third

condition mentioned) is also necessary in order to expedite the operation, and experience has proven that to burn the ore *in suspension*, or while falling from one point to another, thus securing a free circulation of air between the burning particles, is not only by far the most expeditious, but the most successful in producing perfect and uniform results.

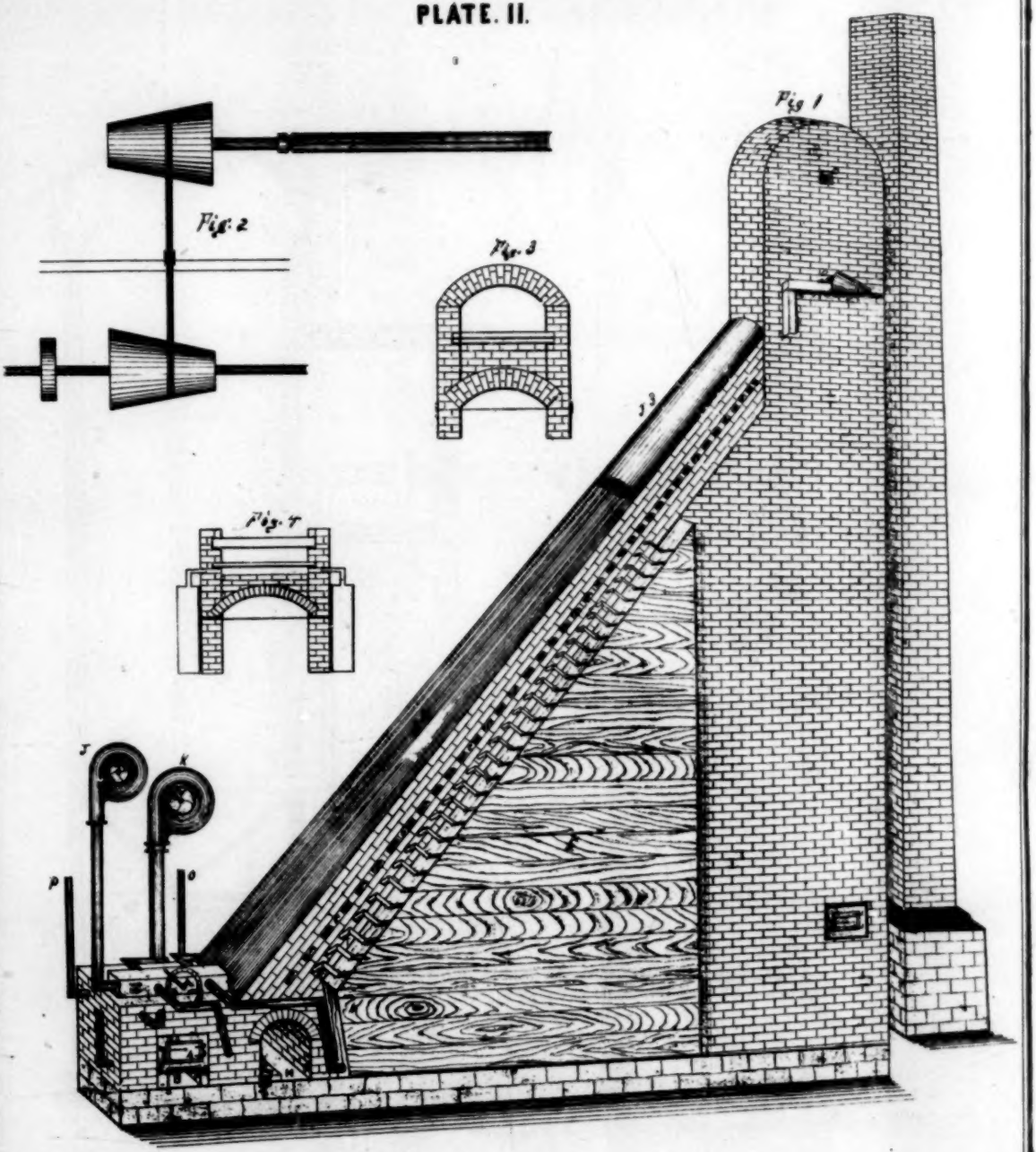
The fourth condition mentioned demands sufficient time to perfect the chemical changes involved in the operation. This will depend entirely upon the perfection of the conditions; that is, upon the more or less perfect adaptation of the means to the end; and, secondly, upon the degree of fineness to which the ore has been reduced. A ton of ore may be roasted in some furnaces for a month without being desulphurized. A revolving cylinder furnace will accomplish the work in ten or twelve hours, while it is claimed that the one herein described will desulphurize twenty-four tons in as many hours.

This may seem incredible to many persons having a practical knowledge of the business *as at present conducted*, but a little reflection, assisted by a few carefully conducted experiments, may remove all doubt. Thus, take the largest particle admitted into the furnace (less than half the size of a pin's head), and bring it under the oxydizing flame of a blowpipe; a very few seconds will be time sufficient to desulphurize and oxidize it.

Now, it will be admitted, that a million or an infinite number of particles can be desulphurized in the same time required for the one, could they all be placed in equally as favorable a condition and acted upon simultaneously; and this is one of the objects sought in the plan and construction of the Phelps furnace. The current of ore, continually running down the terraced floor of the oxidizing flue, is four feet in width by forty in length, and so thin or shallow that each and every particle is exposed uninterruptedly to the action of the heat, flame and air. Each particle is independent of its neighbor, so far as exposure to oxygen is concerned. Each particle is *assisted* by its neighbor to heat and flame, hence there is mutual assistance as well as individual independence.

Again, the time required to desulphurize a single particle depends greatly upon its size, a little difference in its superfices making a very great difference in the time required. Thus, take a cube of pyrites one millimeter across its faces, and let us suppose that it can be desulphurized in ten seconds. Now take another, two millimeters across (only twice that of the first), and it will take *eight times* as long to do

PLATE. II.



Dr. Phelps' Oxidizing Furnace,

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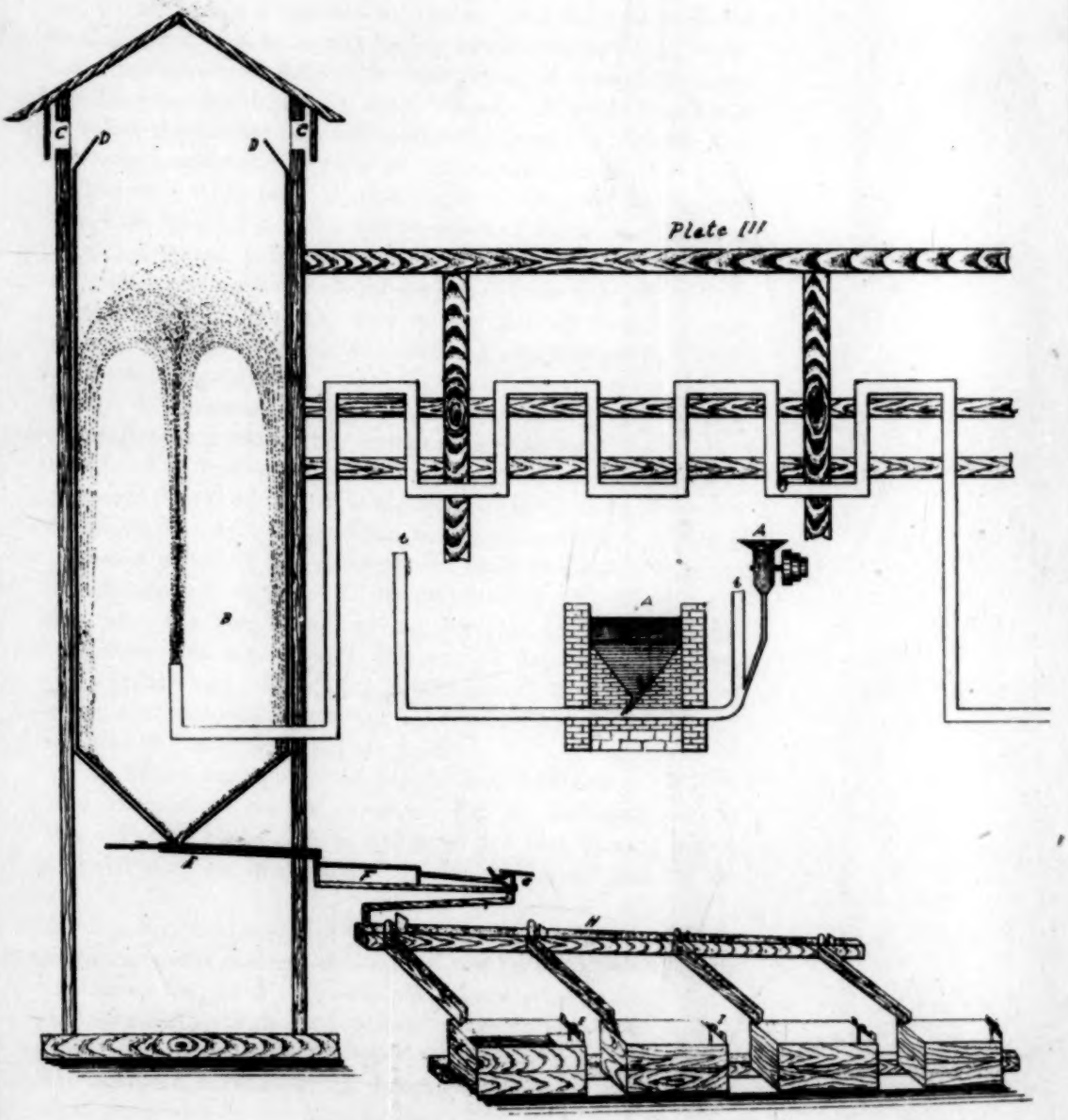
Plate III



Chlorodizing and Cooling Apparatus.

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the work, for the simple reason that its cubic contents are eight times that of the first. So, one three millimeters square will require twenty-seven times as much time for the same reason, and so on *ad infinitum*. Hence, the advantage of pulverizing the ore very finely preparatory to roasting, for if a sieve is used having twenty meshes to the linear inch the time required will be eight times as long as it would be if one having forty meshes had been used. Hence, all other conditions being equal, the furnace that will handle the finest ore, without permitting any considerable portion of it to escape (and the fine gold and silver with it) by force of its draught current, will do the best work and the most of it. This has been one of the great difficulties hitherto experienced, a difficulty entirely obviated by the Phelps furnace, in which the ore is introduced *underneath* the draught current, and passes down the terraced floor of the inclined flue, in a substratum of atmospheric eddies, without being once brought in contact with the ascending current.

In order to understand the construction and *modus operandi* of this furnace reference is had to the accompanying diagrams.

Plate 1.—Fig. 1 is a vertical, central, longitudinal section, showing the arrangement of the terraces, interterrace air slots, subterrace air chambers, &c., &c. A is the fire box, B the ash pit, C oxidizing flue, 4 feet in width, 40 feet in length, and inclined about 50 degrees; E dust chamber, F throat (with damper) leading into chimney, G; H arch, near fire box, containing hot ore pipe, t; I hollow bridge wall; J sheet iron air box with damper; J2 flat roof of fire clay tiles; J3 arched roof; K hopper; L feed roller; m m m terraces of fire clay; n n iterterrace air slots; o o o subterrace air chambers; R feed slot; S discharge; t hot ore pipe.

Fig. 2. Transverse section of hopper and feed roller. Fig. 3. Bisected longitudinal section of same. Fig. 4. Enlarged view of terraces. Fig. 5. Under side of roof over fire box, showing course of hot water pipe for amalgamor, &c. Fig. 6. Ground plan of the furnace.

Plate 2.—Fig. 1. An exterior perspective view of furnace. E atmospheric reservoirs (one on each side of the furnace) receiving air from oxidizing fan, J; F oxidizing pipes, conveying air into subterrace air chambers through perforations in the walls. Each pipe is furnished with a slide valve or damper, and, the quantity of air blown into the reservoirs is regulated by damper m, in air box L; K motor fan, connecting with hot ore pipe, t.

Fig. 2. Feed roller with reversed cone pulleys and belt shifter.
Figs. 3 and 4. Transverse sections of furnace.

Plate 3. t, a continuation of hot ore pipe, into which the ore falls on leaving the furnace, and through which it is blown by the motor fan into cooling chamber B; C ventilators; D sheet iron linging in cooling chamber; E trough of running water into which the ore falls; F vibrating table amalgamator, with contracting arrangement, G; H trough with side pipes, conveying tailings into boxes furnished with syphons, I, and floats for additional concentration.

Modus Operandi.—A gentle current of air passes out from beneath the foot of each step or terrace, from the reservoirs, entering the flue in a *descendiny* direction, and, coming in contact with the *ascending* or draught current, creates a series of atmospheric eddies immediately over the terraces and in the path of the ore. This arrangement supplies a vast quantity of air, in addition to that coming from the fire box, without carrying the fine gold out of the furnace by force of the draught current. The ore is pulverized dry, and passed through a sieve having forty meshes to the linear inch; then conveyed by strap-and bucket elevators to the hopper, from which it is discharged into the flue *underneath* the draught current. As it falls from terrace to terrace it receives a fresh supply of oxygen from the incoming currents of air; is burned "in suspension" thirty times over, in a constantly increasing temperature, and on leaving the furnace falls into another powerful current of air and is blown through a long zigzag pipe, and is thus repulverized while hot and burning, preparatory to amalgamation.

This is, doubtless, the most perfect arrangement for desulphurizing ore in existence, but the process contains another feature, as valuable as it is novel. Allusion is here made to the "chloridizing attachment" shown in plate 3. The salt mill, A, is connected by a narrow tube with the hot ore pipe, between the motor fan and the discharge from the furnace, A′, by means of which a continuous stream of sodium chloride is blown forward to commingle with the red hot ore, and the disengaged chlorine cannot make its escape prematurely, but is confined within the pipe until it reaches the cooling chamber.

Thus the metallurgist has the choice of two methods, in making use of which he will be governed by the character of the ore, and the best net results.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, ON THE RELATIVE EFFICIENCY OF KEROSENE BURNERS.

By C. J. H. Woodbury.

The laws of the State of Massachusetts declare that illuminating gas, when burning in an Argand jet at the rate of five feet per hour, shall furnish light of intensity equal to twelve times that given by one sperm candle, consuming one hundred and twenty grains an hour.

Therefore, it has been for the interests of both manufacturer and consumer to introduce burners which will give the greatest light with the least expenditure of gas. Much skill and ingenuity has been devoted to the attainment of this result. MM. Audoin and Berad investigated this subject very thoroughly, and came to the decision that there is a design of burner adapted to every rate of consumption.

These researches have been very valuable to all using this source of artificial light; but this is restricted to those living near the centre of population in cities; the greater part of our population, residing in suburban towns, unable to procure gas, are obliged to use kerosene.

The comparative worthlessness of the lighter products of petroleum tempt the unprincipled manufacturer to add them to kerosene, making a product which, on account of its extreme volatility, is *cleaner* than pure kerosene; the flame is of greater brilliancy, and, on these grounds, it recommends itself over the pure oil to those who have not been able to give attention to this subject. Many of these compounds are quite as dangerous as gunpowder.

As kerosene has been in use only a few years, a sufficient interval has not elapsed to enable us to burn it with the greatest possible economy.

The laws for the protection of persons using kerosene must be directly antithetical to those concerning illuminating gas, because the deterioration of the first, causes it to better serve the purposes of illumination at the expense of safety to those using it. This protection is afforded by the declaration that the vapor of the oil shall not be inflammable below a certain temperature.

The writer, in the following series of experiments upon various kerosene burners, has endeavored to ascertain the most favorable forms of burner for an economical expenditure of oil compared to the light

given. The results given for each lamp are the mean of from one hundred and fifty to two hundred and fifty observations.

Flat Wicks.

No.	Manufacturer.	Name.	Chimney.	Wick.	Candle Power.	Hours required to consume 1 gallon.	Candle power to gallon.
1	Scovill Manuf. Company.....	Standard.	Bulge	$\frac{5}{8}$″	8·469	99·06	594
2	" " "	XL.	"	"	6·426	127·53	815
3	Perkins and House.....	Hinge.	"	"	6·587	125·35	823
4	Scovill Manuf. Company...	Imperial.	Sun	"	5·138	163·93	829
5	Collins.....	Sun.	"	"	4·879	171·89	830
6	Scovill Manuf Company.....	Imperial.	"	$\frac{1}{2}$″	4·810	174·87	835
7	" " " "	Hinge.	Bulge	$\frac{5}{8}$″	7·398	115·23	847
8	Holmes, Booth and Hayden.....	Sun.	Sun	"	7·371	131·19	964
9	Scovill Manuf. Company.....	Phœnix.	"	"	5·997	188·57	1110
10	Jones, McDuffee and Stratton...	Calcium.	Bulge	1″	10·754	113·17	1209
11	Downer Company	Dual.	"	$\frac{7}{16}$″	19·48	As these lamps were made to burn mineral sperm oil, we do not give the results.	
12	" "	Dual.	"	$\frac{1}{2}$″	10·03		

Circular Wicks.

13	Holmes, Booth and Hayden.....	Argand.	Cylindrical.	8·387	101·20	833
14	Jones, McDuffee and Stratton...	"	"	8.824	103·68	911
15	W. H. Batchelder...	Defiance.	"	10·905	123·68	1347

The list could have been made much longer, but it would serve our purpose no better.

The oil used was Downer's kerosene; sp. gr. 0·801. One gallon, at 62° F., weighing 3025·3 grammes. The first column of results shows the candle power given by the lamp when burning with a full flame, but below the smoking point.

The second gives the number of hours required to consume one gallon of oil.

The object of the third column is to give the economy of the lamp, by a unit, which is the candle power given by an ideal lamp, exactly similar to the one under observation, with the exception that it shall consume precisely one gallon of oil an hour.

This result is constant for all except extremely high or low flames.

Such a unit is very empirical, but no more so than the modulus of elasticity, or absolute zero.

If we merely show the phenomena of some lamps differing from others, without the probable circumstances tending to produce such differences, we should not have accomplished our object.

A simple inspection of the above lamps shows their economical re-

sults to be in the direct ratio to the facilities afforded the air for approaching the base of the flame. Where the air cannot enter freely, much of the oil seems to be volatilized without combustion.

The best example is given by cases 5, 8, 9 and 10. The lamps are all similar, except in the difference noted below, and are of the pattern generally known as "sun burners."

In the first example, the air must pass through two horizontal brass diaphragms at the base of the chimney; one is pierced with holes $\frac{3}{8}''$ diameter, the other about $\frac{1}{16}''$. Case 8, one fine diaphragm at base of chimney. Cases 9 and 10, the base of the chimney is open; a diaphragm is near the base of flame.

Although the two lamps are different in size, they are identical in principle, the following being the cause of difference in the result:

A certain portion of the light is shaded by the top of the burner. This conceals an equal amount (not proportion) of the flame, whether it is high or low. Also, a large flame makes a much more powerful draught than a smaller one. If we have two similar lamps, the larger one will give the best results.

In the four lamps just cited, if we remove the coarse diaphragm from the first lamp, we increase its efficiency 16 per cent.; in addition, taking away the fine one, we increase it 18 per cent. more; make the draught more powerful by a bulge chimney, and we have a further increase of 12 per cent. Lamps like 9 and 10, from their open construction, are extremely sensitive to currents of air.

The Perkins and House lamp (No. 3) is a metallic lamp, and very thoroughly constructed. The air is supplied from the base of the lamp, the burner being closed; it is not sensitive to currents of air, and gives the most steady and agreeable flame of any that have come under observation. If the entrance to the air passage was made larger, and the diaphragms in the burner were pierced with larger holes, the efficiency of the burner would be increased greatly, while it would probably retain its steadiness of flame.

In lamp No. 15 the air is introduced into the centre of the flame with less obstruction than in the two previous cases, and this lamp gave the most economical results.

LIGHTNING AND LIGHTNING-RODS.

By John M. Mott.

Read before the Meteorological Section of the Franklin Institute.

Lightning is atmospheric electricity moving through bad conducting matter under an explosive form.

A lightning-rod is a conductor of electricity so applied to an object as to prevent the accumulation of free electricity upon it, by induction, and also to enable it to transmit, in safety, the electric force by which it may be assailed.

The prevailing disposition of the times is to apply the discoveries of natural science to useful purposes, and to embody them in those material forms which make them subservient to the wants of man.

Theoretically, indeed, the study of electric phenomena awakens a lively interest in every mind, both on account of the wonderful developments which are constantly made and the subtle and mysterious nature of the unknown agency; seeming, as it does, to occupy the interval between mind and matter.

The construction and application of lightning rods has appeared to most persons a matter too simple to need aid from scientific minds, while not a few have looked upon the whole theory as absurd, and as a source of danger rather than of safety. There has been, consequently, but little encouragement for presenting to the public those facts which are requisite for guidance in applying the discovery of Franklin, successfully, to the protection of life and property.

The fact of electrical conduction by metallic substances having been long and well established, any further discussion of the application of this principle to the purpose of protection against injury by lightning may possibly appear, to persons conversant with such subjects, in some degree superfluous. The damage, however, which so frequently occurs in thunder-storms, attended, as it is, with loss of life and with serious inconveniences to the best interest of the country; the various theories advanced by persons who have only partially considered the facts; systems of rodding which have been adopted in different localities, and the numerous modifications of the conductors, each claiming some peculiar advantage over all its competitors, has created a curiosity, if not a necessity, which seems to call for investigation and may be fairly offered as a sufficient reply to such an opinion.

Many lives and a vast amount of property are constantly and needlessly jeopardized.

How the great risk is incurred and safety attainable I will endeavor to demonstrate.

The years 1745 and 1746 mark an important era in the history of physical science.

Von Kleist, Dean of the Cathedral of Kamin, and some Dutch philosophers in the University of Leyden, in endeavoring to confine electricity within the limits of a small phial, discovered a method of accumulating it on glass to a most unprecedented degree, and of subsequently discharging it through bodies in such a way as to produce most powerful and astonishing effects.

By these discharges, a fearful sensation could be impressed upon living animals, even life itself destroyed; metallic substances could be violently heated, fused and ignited; inflammable bodies set on fire, and the most compact substances scattered in pieces, as if acted on by a violent expansive force. When, therefore, lightning became identified with ordinary electricity, with the very element, as it were, by which such effects were produced, and the wonderful attempt of Franklin, about seven years afterwards, to *conduct* electricity from the clouds, and appropriate it in a similar way to the purpose of experiment, had fully succeeded, then it was that those artificial accumulations and discharges acquired a more than ordinary interest, as furnishing us with a valuable means of investigating, by minor experiments, the laws and operations of the great discharges in thunderstorms.

When we consider the coincidences of lightning and ordinary electricity, together with the fact that atmospheric electricity may be conducted from the clouds, or strata of charged air, and applied to produce the same effects as those resulting from electricity generated by means of an electric machine, it becomes quite evident that the causes, whatever they may be, of ordinary electricity are identical with those of lightning; consequently we arrive at the important conclusion that lightning and common electricity are subject to the same laws— a deduction which cannot be too forcibly insisted on, involving as it does the most valuable practical consequences.

The accumulation of electricity by artifical means may be carried to an almost indefinite extent, and is equally manageable whatever may be the extreme limit of force we choose to assign to such accumulation. It therefore necessarily follows that discharges of atmospheric electricity may be quite as easily directed by a judicious and scientific arrangement of conducting bodies; such discharges being,

in fact, nothing more than discharges of the same force accumulated in a similar way by means of an apparatus of a perfectly similar kind.

The vapory masses of electrified clouds opposed to the surface of land or sea oppositely electrified, by induction, with the non-conducting medium, air, intervening, constitute a battery of enormous power.

The circumstance of the coatings of the Leyden jar being metallic, while those of nature consist of clouds and opposed land or sea, is a difference of no consequence whatever, especially when we consider that the original Leyden jar of the Dutch philosophers consisted of a phial filled with water, from which they obtained so severe a shock that one of them said he would not again receive it for the whole kingdom of France.

It is conceded that the atmosphere contains free, or uncombined, electricity; that clouds as they pass through the air collect and retain it in large quantities, thus becoming electrified bodies; that they are sometimes positively, sometimes negatively charged; that it is impossible to have a body charged with one kind of electricity without having an equal amount of the opposite kind accumulated in near or distant bodies; that the attraction between the opposite electricities is mutual, and that it increases as the distance diminishes.

It is well known that an electrified cloud acts upon the earth by induction; decomposes the combined electricity in every object over which it passes; repels the electricity of the same kind as that contained by itself, and attracts the opposite kind. The earth and objects beneath an electrified cloud are in this manner charged by induction. When the attraction between the opposite kinds of electricity becomes greater than the resistance of the intervening air a discharge takes place. It is this accumulation of free electricity upon buildings, by induction, which offers the attraction for the opposite electricity contained in the electrified cloud, or stratum of atmosphere, that causes them to be struck by lightning. The accumulation of free electricity in large quantities is the necessary condition, and the effects follow as a natural consequence. Thus his Majesty's ship Dictator was struck and damaged by lightning at Martinique, in the year 1794, during fine weather and a clear sky.

If a discharge takes place, from any cause whatever, at any point, the cloud is left in a neutral condition, induction instantly ceases, and all the bodies charged by induction instantly return to a neutral state.

The suddenness of this return is what is known as the return stroke, and often kills men and animals, or destroys buildings which are at the time at a great distance from the place where the direct discharge occurs. All the terrible effects of the return stroke may result when the direct discharge has been between two oppositely electrified clouds.

Nothing attracts electricity except electricity of an opposite kind. All substances conduct it in a greater or lesser degree. Metals offer less resistance to its passage than other substances.

If a disruptive discharge takes place between oppositely electrified bodies, it will pass through the line or lines which, upon the whole, offer the least resistance to the neutralization of the electric forces.

Both time and space are, as it were, economized; for, however small we assume the duration of the discharge to be, or however limited the distance through which it strikes, both these, time and space, would be still less were other lines of discharge provided of still less resistance. This is the leading phenomenon of all disruptive discharges; hence lightning seizes upon such bodies as lie convenient and ready for its transmission, actually avoiding other bodies, however near, from which it cannot receive assistance.

It is a most wonderful and interesting truth, demonstrable by the laws of induction, that, at the instant before the discharge takes place, the electricity, in the act of moving to restore the equilibrium, feels its way, as it were, in advance, and absolutely marks out the course it is about to take, by the polarization of such bodies as form the line of least resistance. This previous polarization of the line of best conduction determines the course of the discharge. Its progress, therefore, is not, as many suppose, left to the chance of the instant, to be drawn aside by metallic bodies at any given point. On the contrary, the whole course of a thunderbolt is fixed and determined before the discharge occurs.

FIG. I.

The evidence deducible from observation, as well as from physical investigation, is most conclusive on this point.

In the accompanying cut, C represents an electrified cloud; E, the earth; N P, a

good conductor, suspended between the cloud and the earth. If the cloud be charged with positive electricity, the rod will be polarized as indicated; that is, the upper end of the rod will be negatively charged, and the lower end positively charged, and the earth will be negatively charged. If we assume the cloud to be charged negatively, the polarity of the rod would be reversed, and the earth would, in that case, become charged positively.

The cloud, situated as shown in the diagram, might be so far removed from the earth that the mutual attraction between the positive electricity contained by the cloud and the negative electricity contained by the earth could not overcome the resistance of the air, consequently there could be no discharge.

If we suppose the cloud to be moving through the air, we can readily see that the earth now immediately beneath the cloud would gradually return to its normal condition. The effect of placing the conductor, N P, between the cloud and the earth, as shown in the cut, would be to lessen the resistance between them, by offering a better line of conduction than that offered by the intervening air. If a discharge should occur while the rod is in the position indicated, it would become part of the line of discharge determined, by polarization, before the discharge took place, and not by attraction after the electricity had started to restore the equilibrium.

If the rod be disconnected from the earth, any conducting body between it and the earth would also become part of the line of discharge, while insulating matter would be attacked with destructive violence.

This diagram is intended to illustrate the contempt architects and builders display of electrical laws in the erection of high spires, which are frequently terminated with a metallic shaft attached to a cross timber within the tower, and supporting a gilded ball or ornamental vane. They also have metal clamps and strings of lead, the former uniformly placed at intervals from each other, and the latter wantonly poured into the crevices of the masonry, which makes the spire a complete chain of alternate links of metal and masonry from top to bottom, the former offering a safe line of conduction, so far as it goes, and the latter facilities for the most destructive explosions.

It is almost a miracle that the whole of them, instead of a part only, are not destroyed by lightning. It also illustrates the condition of buildings having metallic water conductors or lightning-rods disconnected from the earth (the owners of which know the fact, but,

from ignorance or indifference, allow them to remain in an improper and unsafe condition), and that of every building having gas or water pipes which are not connected with lightning-rods extending to the top of the structure and terminating in points.

We have stated that the rod N P would facilitate a discharge between the cloud and the earth. It is immaterial how that rod is supported, or for what purpose it may be used, as it offers a line of less resistance to the restoration of the electric equilibrium than the materials from which buildings are constructed, and is, therefore, likely to become a part of the line of discharge, in case of a direct or return stroke. In case damage ensues to a building from lightning, it will not be where good metallic conductors are continued.

In the following cut, Fig. 2, we have C, the charged cloud, and, beneath it, B, a building.

FIG. 2.

In this case we represent the cloud as being negatively charged; the building will be positively charged by induction, as indicated; A is a chimney, with smoke escaping from it into the air. In case a discharge should occur while the cloud is immediately above the building, the smoke above the chimney, the inside of the chimney, the stove-pipe and stove would be most likely to be the line of least resistance, and consequently would become part of the line of discharge, should an explosion ensue.

If the cloud be approaching the building from the left, the cone of the roof at D would be the nearest geometrical point; it would also be the most highly charged point of the building, as the free electricity of the building would be attracted by the opposite electricity contained in the approaching cloud, and would tend to accumulate upon that portion of the building, in accordance with well known laws governing the accumulation of free electricity upon bodies when differently situated with respect to oppositely electrified bodies; it would offer greater attraction than any other portion of the building; hence it would be most likely to be struck in case a discharge should ensue while the cloud is approaching the building from the left. We have already stated that it is not the materials of which the building is composed that offer the attraction, but the free electricity held on

it by the attraction of the opposite force contained by the approaching cloud. The nearer the cloud approaches the building the greater becomes the accumulation of free electricity upon it, and as the distance diminishes the attraction increases.

If, while the cloud is at the left of the building, a rod, K, terminated, as shown, in a ball, be placed in contact with the building at D, it will conduct the free electricity from the building to the ball, which will show its electrical condition if an electrometer be attached to it. It is evident that the ball and rod will become part of the line of discharge as soon as the electrical attraction is sufficient to overcome the resistance. Any means which will prevent the accumulation of electricity by induction at the point D, will prevent the building from being struck at that point.

There is one law of electrical action which some electricians lose sight of entirely in considering the subject under immediate investigation, viz., that large quantities of electricity pressing upon small surfaces become quite unruly, and when the surface is reduced to a mere point the tension becomes so great as to give rise to an escaping current. If, instead of terminating the rod K in a ball, we use a finely plated point, as shown on the rod H, attached to the building at E, we will at once have a flow of free electricity from the building into the air by means of the rod and point, and as the particles of air become charged they will be repelled by the electricity being conducted from the earth by the rod, and attracted by that contained in the cloud. The escape of electricity from the points of the electric wheel, and the effect produced upon a charged conductor, when slowly approached with a metallic point, held in the hand, are demonstrations of the fact that electricity escapes from points, and neutralizes charged bodies with which they are not in contact. Thus it will be seen that a pointed conductor, placed directly in contact with a building, tends to prevent the accumulation of electricity upon it, and also to neutralize the charged cloud; hence it may prevent a disruptive discharge which might otherwise occur. If the rod be removed from the building by insulation, it is powerless to prevent the accumulation of electricity on the building by induction; hence by insulating a rod we lose its most valuable influence. If the rod be insulated while it has a tendency to neutralize the cloud by conducting and discharging the opposite kind of electricity from the earth, it may also facilitate a discharge, for the reason fully explained in connection with Fig. 1. If a discharge falls upon an insulated rod, and be con-

ducted by it to the earth in safety, and without intermediate explosion, still the conditions requisite for a return stroke are present, and the insulated rod is powerless to prevent injury to the building or its contents at the *very instant* of the direct stroke.

Phenomena of this character are quite frequent, especially where buildings have gas or water pipes to lead the return stroke into the house, and in consequence many have condemned the use of lightning-rods without investigating the cause of the disasters.

The closer rods are applied to the walls of a building the better; indeed, it is absolutely necessary to attach the rod directly to the object to be protected, to insure safety, for no other way can we guard against the return stroke, which kills more people and destroys more property than the direct stroke.

The rod must not be placed at a distance from the object to be protected, nor pass over nor through rings of glass or other insulators. Insulators are not only useless but are positively dangerous before rain falls; after rain falls they acquire some degree of conducting power; at best, they are entirely useless as a means of safety, make an insecure fastening and allow the rod to rattle sufficiently to disturb sick or nervous people at all seasons of the year. Their use should be discontinued, and some method taken to induce parties, having rods upon their buildings which are insulated, to remove the glass.

It is a physical impossibility for any object to be injured by lightning if the conditions of safety, known to be demanded, are fully complied with.

I have no doubt but the case mentioned in Sillman's Physics, page 662, second edition, illustrates the result of insulation. It is stated: "In a church in New Haven the lightning has twice penetrated a 20-inch brick wall at a point opposite a gas pipe 20 feet above the earth, although the conductor of $\frac{3}{4}$-inch iron was well mounted, but its connection with the earth was less perfect than that of the gas pipe." I suppose "well mounted" to mean well insulated. Now, suppose lightning to fall upon this well insulated rod and be conducted by it to the earth in safety, or a discharge to take place between two clouds. In either case the building would at the same instant return to its normal condition, and the gas pipe would be part of the line over which the electricity would pass to restore the equilibrium. The effect produced by lightning on this church upon two different occasions are such as might have been anticipated, and are likely to occur

again, unless the rod be attached directly to the building, *and also to the gas pipe* near its upper terminus. It will make but little if any difference at what point the rod and gas pipe are united; if the connection be made about the building it will be less liable to get out of order than it would be if made in the earth. It is contrary to all known laws of electrical action to suppose that electricity, passing over a rod which penetrates the earth, would leave such conductor before reaching its termination, unless some other equally as good a conductor is in contact with it and also extending to the earth, in which case the charge would be carried in part by each without injury to surrounding bodies, providing one of the conductors be a ¾-inch iron rod.

The distribution of free electricity over the surface of electrified bodies, depends upon their form and the position which they occupy with respect to surrounding bodies.

It is conceded that the greater the curvature of a surface at any part, that is, the nearer it approaches a point, the greater will be the accumulation of electricity there; that electricity tends to flow towards, or accumulate at, the pointed portions of bodies; that metallic bodies of a pointed shape soon lose the electricity imparted to them, and that it is impossible to charge a conductor when a sharp point projects from it, or one having conducting communication with the earth is held near it. Points are of value aside from preventing the accumulation of electricity on the object to be protected and their tendency to lessen the intensity of the cloud. Having become the origin of an active mechanical force, do, by the very act of causing that force, namely, by discharge prevent any other portion of the conducting body from which they project from acquiring the same conditions, and thus preserve their own predominance.

A geometrical point is without dimension. A practical point has dimensions which are, in comparison to some other body, quite insignificant. Some electricians, still accepting the absurd one-fluid theory of Franklin as being true, claim that points draw off electricity silently and quietly from charged bodies with which they are not in contact; that a cross section of any lightning rod would be an infinitely small point in comparison to a cloud, and therefore the points upon lightning rods are useless except as ornaments.

The cross section of a lightning rod would be, as claimed, an infinitely small point in comparison to the area of a cloud; but, unfortunately for the advocates of the one fluid theory, points do not re-

ceive electricity from charged bodies with which they are not in contact, except in cases of disruptive charge.

The silent flow is always from points, never towards them. Electricity cannot leave the cloud except by conduction or disruptive discharge. The upper termination of a lightning rod must be a mere point in comparison to a cross section of the rod upon which it is used. The object in terminating the rod in a point is to increase the electrical tension at its upper extremity sufficiently to give rise to an escaping current of electricity from the rod. If the upper portion of a lightning rod be insulated and separated from the lower section by a slight opening, electric sparks will pass through the space during the passage of electrified clouds so rapidly that neither the eye nor the ear can discover the intermissions. If the point be removed the sparks will cease. This experiment demonstrates the value of points and proves that lightning rods do tend, as before stated, to neutralize charged clouds. If the upper end of rod, N P, Fig. 1, be terminated in a ball, or be inserted into the mouth of a glass bottle, a disruptive discharge would be through the conductor, as it would still be the line of least resistance. At the instant of discharge, it is a matter of but very little consequence whether the rod be terminated in a finely plated point or within a pop bottle. Polarization will take place nearly as well through glass as through dry air. I have not the slightest doubt but buildings would be destroyed by lightning, either by the direct or return stroke, were they encased with glass coverings one half mile thick. Points are of vital importance before the instant of discharge arrives.

(To be continued.)

Removing Phosphorus from Iron.—Some improvements in effecting the removal of phosphorus from pig-iron during the puddling process, have been introduced by Prof. Scheerer, of the Mining Academy of Freiberg, in Saxony. Chloride of sodium and chloride of calcium are mixed in about equal proportions, and the two salts are fused together. The fused mixture is run into water-proof paper cases, each holding about two pounds, and these cases are introduced into the furnace one by one, so that the dephosphorizing mixture may be thoroughly incorporated with the charge. To insure satisfactory results, it is recommended to use three times as much of the mixture as the iron contains phosphorus.

DECAY AND PRESERVATION OF TIMBER.

(Continued from page 53, Vol. LXVI.)

Measure of Economy in using Creosoted Railroad Ties in the United States.—As a general rule in this country, ties untreated last about seven years before they require renewal. We have a right to suppose the treated ties endure as long as the average in foreign countries, which I find is twenty-eight years, and then perfectly sound; but to be on the safe side of our estimate of economy, suppose the treated ones should give out at the expiration of twenty-eight years and then require renewal. Constructing the road at first with untreated ties; after that, there would be four renewals with the untreated in this period; but as the last renewal would belong to the next epoch, we have to set the cost of four constructions (*i. e.*, the first construction and three renewals) with the untreated against the cost of one construction with the treated ties.

All railroad companies pay interest on funds for construction at a rate of not less than six per cent. per annum. This interest item should enter into the estimate.

On the different roads traversing our country the price of ties, the cost of the labor in laying them, and the cost of treatment vary, though not very materially. We will suppose these prices to vary, however, and let

T be the average cost *in cents* per untreated tie on any road, delivered where the tie is laid in the track.

L the cost per tie *in cents* of the labor of laying the tie in the track where it will require renewal every seven years.

ψ the cost *in cents* of treating the ties before laying, at some convenient place for the location of the apparatus for treatment.

And by taking the interest only at six per cent. on the outlays, the interest paid only annually instead of semi-annually, and compounding it, for the four outlays, seriatim, from the time each is incurred to the expiration of the epoch of twenty-eight years, I make the following formulas:

$$\left.\begin{array}{l}\text{Cost in cents per tie untreated, for twenty-eight years,} = 12.276 \times (T + L) \\ \text{Cost in cents per tie treated, for twenty-eight years,} = 5.112 \times (T + L + \psi) \\ \text{Saving in cents per tie by treatment, in 28 years,} = 7.164 \times (T + L - 5.112 \times \psi)\end{array}\right\} \quad (1)$$

APPARATUS USED IN CREOSOTING TIMBER AT St CLAIR FLATS, MICH.

PATENTS OF SEELY & PELTON.

Accompanying Report of Genl. T. J. CRAM, U.S. Corps of Engineers, to the Chief of Engineers, U.S.A.

1871

Fig. 3.

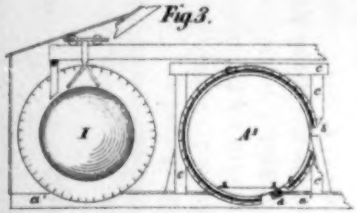

Fig. 1.

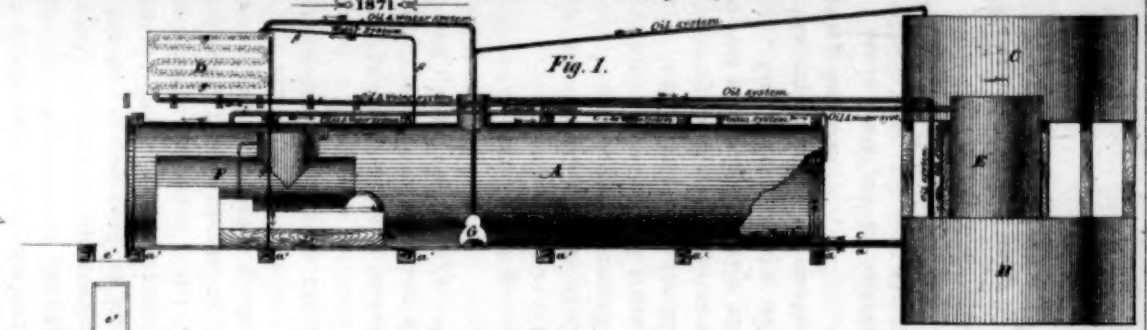

Fig. 4.

Fig. 2.

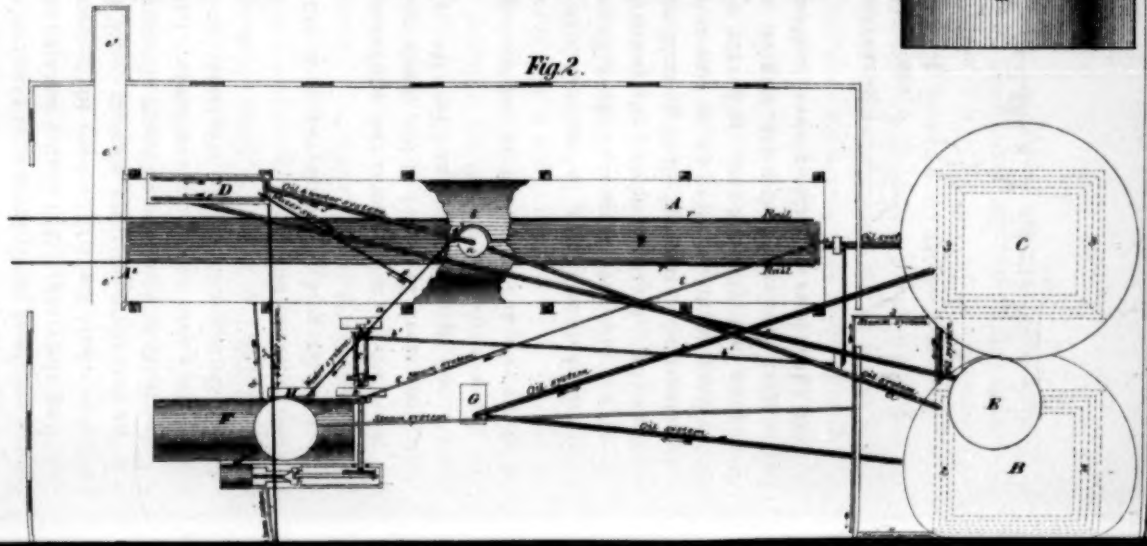

Fig. 6.

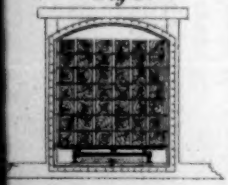

Fig. 5.

These formulas (1) being applicable to any road. Suppose, for example, we apply them to one upon which T=42 cents, L=25 cents, and ϕ=35 cents. Substituting these in (1), we shall find

Cost per tie untreated, for 28 years=$8.22.

Cost per tie treated, for 28 years=$5.21.

Saving per tie by treatment, for 28 years=$3.01.

The saving would be 10.715 cents per tie, annually, which would be 25½ per cent. of first cost of the untreated tie.

On a mile of road, there would probably be 2,376 ties, for heavy work on the track. The saving per tie (10.715 cents) applied to this number, would make the saving to the company, by treating the ties in the first laying of them, amount to $254.58 per mile per annum.

But there is a limit to the cost of treatment beyond which there would be no saving to the company. Let ϕ' represent the limiting cost in cents per tie for the treatment, and we shall have in any road, $\phi'=1.4\times(T+L)\ldots$ (2), from which, by substituting the values of T & L, we shall find ϕ'.

In the foregoing example, where T=42 cents, and L=25 cents, we shall find ϕ'=94 cents, nearly.

We may say as a general rule applicable to all railroad tracks that a treatment which would make the ties last only for twenty-eight years, and should cost one and four-tenths (1.4) of the sum of the cost of the untreated tie and of the laying of the tie, there would be no advantage in the treatment as long as money could be had at six per cent.

In the United States, the price of ties has been progressing since wood was first used instead of stone bearers, A. D. 1862. In 1838, I remember, fourteen cents per tie was a full price per tie for oak and chestnut of the best quality, in Maryland. The price will hereafter keep advancing until some process of treatment shall enable us to use an inferior quality of timber for them. Wood that will hold the spikes the best and last the longest, is the desirable kind.

III. *Processes of Treatment.*—It certainly seems that the mode of treatment which shall insure the most perfectly, the following conditions would be the most effectual in preserving the wood:

1st. To displace or destroy the albumen and the natural acids in the wood, and empty its pores of all corroding or fermenting substances.

2. To infuse into the pores thus emptied a powerful antiseptic, which in itself will not weaken the fibre, and at the same time be in-

soluble by water, and of a tenacity to resist being soaked or washed out, and thus preventing admission into the pores of all extraneous matter.

3d. To be exempt from deleterious effects upon the health of the men employed in conducting the process, and of those who handle the treated wood for the construction.

It is obvious that, whatever process be used, the greatest care should be taken to guard against injury to the fibre. Injury has arisen and will again arise in the multitude of processes starting up all over the land, from the corrosive nature of the quack antiseptics; also from too much heat in the application. Kyan's process, dating back to the year 1832, although he claimed that timber treated with it resisted rotting substances in vats for 23 years, and was then as sound as ever, signally failed to answer conditions 2 and 3. It utterly failed to resist the sea worm, and produced such sickness in the employes as to condemn its use.

From the results, however, of the experiments quoted in Tables A, B, C, Chapter II, it will be acknowledged that Bethel's process in England, dating back to A. D. 1838, answers to the three conditions I have named, better than any practiced from the time of Kyan's to that of Seely's in the United States in 1867.

Bethel's was named "creosoting," and still bears that appellation, though a misnomer. From the first, his method has consisted in using what was called "creosote oil" in England, "pitch oil" in Scotland, and "dead oil" in the United States, and which is either distilled from that substance (coal tar) left in gas factories after the illuminating gas comes off from bituminous coal, or directly distilled from the coal itself. It is considered to be heavier than water at the same temperature.

Bethel applied this oil by putting it with the wood into and nearly filling a strong iron receiver, then closing the receiver, and forcing more oil into the receiver until the pores of the wood become saturated, requiring a pressure of 13 to 14 atmospheres.

Now, while this mode of application, which I believe is still followed in England and at Rotterdam, would be sufficiently good perhaps, for *well seasoned wood*, any one can see it is illy adapted to *green, wet, or unseasoned* timber, because the sappy and other fluids inherent in the pores would not be expelled before the admission, indeed, they would virtually prevent the admission of the antiseptic. Remedies have been sought in soaking, steeping, and boiling the wood in the oil; also in

steaming, but without much success. The boiling point of the oil is high, 500° to 600° F. This degree of heat, as also previously subjecting the wood to a steam bath, produced bad effects on the fibre.

It is obvious, the process to be of the widest practical benefit, should enable us to treat green, wet or water-logged sticks of timber, 30 to 40 feet long and 10 to 12 inches through, and even larger sticks for piles.

The method of application patented by Professor Charles A. Seely, of New York, in 1867, is a modification of, and an undoubted improvement upon Bethel's process, in being applicable to green, water-logged wood, and with far more efficiency even to seasoned wood, differing materially, however, in the mode of application of the dead oil.

This new process consists of immersing the wood in a closed iron tank of the oil, raising the whole to a temperature between 212° and 300° F. This action is allowed to go on until the moisture or water contained in the wood is expelled, or has escaped in the shape of steam. The water being supposed thus expelled, and the pores containing little or no steam, the hot oil is suddenly replaced by a bath of cold oil, condensing all the remaining steam, and thereby leaving a total or partial vacuum in the wood cells, into which the oil immediately rushes, impelled by the hydrostatic pressure of the oil, the pressure of the atmosphere, favored also by capillary attraction.

Those who favor this process claim for it the following results:

1st. The effect of the hot bath is to sufficiently season the wood, and destroy or coagulate all the albumen and expel the water and other fluids from the pores.

2d. The effect of the cold bath is to impregnate the wood cells with the antiseptic (carbolic acid), and at the same time stuff, as it were, the pores that will for a long time after exposing the timber to the air, variations of atmospheric temperature, soil, rain, salt or fresh water, resist absorption of destructive agents in all these sources, the borers in salt water, worms on land, and white ants in tropical climates inclusive; and also prevent the rusting of iron bolts, spikes, nails, etc., in treated wood.

The stuffing substance with which the pores are filled, is supposed to be tenacious and insoluble in fresh or salt water. It is called "hydro-carbon," or "resiniform." I am inclined to believe this is the substance, from the fact that in the arts, if the dead oil is carried through another stage of distillation, a very useful varnish is obtained, having great preservative qualities for heavy linings under the sheet-

ing boards of houses. But this is an unnecessary digression; nor do I intend to give a chemical analysis of this substance.

The lapse of time and then careful observation are the only means of certain tests for the efficacy of this or any other process.

Knowing that Bethel's had effectually preserved seasoned timber 21 to 32 years, which was then reported to be as sound as ever in foreign countries, but believing his method illy adapted to our green, wet timber, and believing Seely's process could be made suitable for this kind of timber, I recommended the adoption of it on the 6th of April, 1868, for the timber *above water* in the U. S. public work, known as "St. Clair Flats Ship Canal, Mich."

The recommendation was appreciated and promptly approved by the chief of the U. S. corps of engineers, Bvt. Major-General and Brigadier-General A. A. Humphreys.

Accordingly I made a contract with W. T. Pelton, of 157 Broadway, New York, who controlled the Patents, to treat the timber, he doing and furnishing everything, except the timber, for fifteen cents per cubic foot, receiving the timber at the hands and convenience of the constructing contractor, and placing it after treatment convenient for the latter to take away, for framing and putting the treated timber into the dykes of the canal.

After getting the apparatus completed, the application of the oil was commenced in May, 1869, and finished 15th June, 1870.

The timber was of superior quality, well-sawed Michigan hard and white pine, (the first called by some red and by others Norway pine.) This kind in Michigan has very little resin in it. The logs for this timber were cut in winter and sawed in the following spring and summer; some were rafted from the mill to the work, some were brought in vessels, and taken green and water-logged immediately and put through the process.

The sticks were in sizes $12'' \times 12''$, 20′ long; $10'' \times 12''$, 20′ long; $8'' \times 12''$, 20′ long; $8'' \times 10''$, 14′ long.

The total amount treated was, 186,580 c. f.

It would be very difficult to fully understand the method of applying the "dead oil," without a knowledge of the apparatus. I therefore give the explanation and drawings of the apparatus in the next chapter, which I advise every reader of this to carefully notice. This apparatus, I understand, was patented by the said Mr. Pelton, for the particular application of Professor Seely's process.

IV. *Construction and Mode of Working the Apparatus for treating*

of the dike timbers by Seely's process, for the St. Clair Flats Ship Canal. (*Treatment commenced May* 5, 1868, *terminated June* 15, 1870.—On the accompanying sheet of drawings, Figs. 1 and 2, are vertical and horizontal projections showing the relative positions of the parts of the apparatus.

The timber tank A′ A (Figs. 1 and 2) is a cylindrical vessel made of boiler iron, only three sixteenths of an inch thick, forty-five feet long, with an interior diameter of eight feet. In Figs. 1 and 2, portions of the surface are represented as cut away to show the positions of the steam coils at ξ and η and the rails *r*, *r*, on which the timber cars are drawn.

One end of this tank is closed by boiler iron plates riveted as ordinary boilers, and strengthened by heavy iron braces, not shown in the drawing, while the other end is to be closed or opened by a cast iron cover one inch thick, seen in Fig. 3, at 1. This cover is nine feet in diameter, with a radius six inches longer than that of the tank, that it may fit the cast iron rim which is riveted around the head A′ of the tank. A cross section of the rim on a large scale is represented in Fig. 5. At *e*, in the same Fig. 5, is represented a cross section of a groove filled with an india rubber band corresponding.

Part of the surface of the cover is pushed out as it were, and the cavity left is crossed by ribs deep in the centre to give strength. In the periphery of the cover and rim, corresponding slots are left large enough to admit of the easy sliding in and out of $\frac{3}{4}$ inch bolts; by this arrangement the cover is put tightly on or taken off at pleasure. It is needless to remark that when on, the cover must fit "oil-tight."

The firm bed upon which the timber tank rests is made of six pieces of square 12″ 12″ timber laid eight feet apart in compact sand, the cross section of which is shown in Fig. 1, at *a*', and seen in side elevation in Fig. 3, at *a*'. Across this, parallel to the axis of the tank and directly under the rails *r*, *r*, which are in the tank, are two pieces of $6'' \times 8''$, shaped on their upper surfaces to lay well against the surface of the tank and let into their bearing ($12'' \times 12''$) pieces, as seen at *c*, *b*, Fig. 3.

To prevent warping or flexure, a frame of $8'' \times 8''$ timbers on each side of the $12'' \times 12''$ bed pieces is arranged to support the tank as shown at *c*, Fig. 3, assisted by intermediate studs capped with a wrought iron ear riveted to the tank, as seen at *b*, Fig. 3.

This tank A' A with the steam engine boiler F, the condensing tank D, and the engine and pumps are covered in from the weather by a slight roof, but the tanks B, E, C, are in the open air.

For convenience I divide the many pipes connecting the various tanks into four systems, as follows:

1st. The "oil system," or those pipes conveying oil, lettered with *italics*.

2d. The "oil and water system," those that convey the vaporated oil and sap from the timber tank to the condensing tank D, and the condensed liquids to the wooden receiver. This system of pipes is also lettered with small *italics*.

3d. The "water system," or those conveying water, lettered with small Greek letters.

4th. The "steam system," those conveying steam, outlined in black, or indicated by broken black lines and lettered in Greek, or indicated by figures.

These systems are so arranged as to allow all the liquids to be drawn from them when necessary, to prevent freezing and bursting.

Let us suppose a bill of timber 12×12's, 8×12's, and 6×12's, twenty feet in length, is on hand for treatment. Two cars are loaded with these timbers (called a "batch") by means of a swinging crane, the pieces arranged as seen in Fig. 4, cross section. The loaded cars are then hauled into the tank by means of a rope b', Fig. 2, rendering through an aperture in the end of the tank, and wound over the drum c'; this aperture is closed with a plug when the rope is detached from the load.

The batch being drawn to its place in the tank, the moveable parts of the track *r*, *r*, Fig. 2, spanning the trench *e'* are removed, the cover drawn over the head of the tank and firmly bolted. In the meantime, the oil tank B, made of boiler iron, and sunk in the ground so its top is thirty inches above the ground surface, has been filled with oil directly from the barrels, and the oil pumped from B, through three inch pipes *a*, *b*, Figs. 1 and 2, into the iron tank C (which is raised entirely above the timber tank and rests on a stand framed with timber), by a rotary pump G, worked by a band from a band wheel *k* on the crank shaft of the engine.

Now the valve in the five inch pipe at *c*, Figs. 1 and 2, is opened, and the oil from C rushes into the timber tank and is allowed to cover the batch to the height of three inches above all the timber, which height is tested by a stop-cock in the end of the timber tank. As soon as this rushing in of oil commences, the valves in the one inch pipe ε are opened and the steam from the boiler F is forced through it with a pressure of about three atmospheres, into the upright steam

coil ξ, Fig. 1, in vertical and in horizontal projection ξ, Fig. 2; thence into the horizontal coil seen lying between the rails *r*, *r*, at η, Fig. 2, and in cross section at η, Fig. 4. From this coil the steam finds its way into the open air through pipe δ, Fig. 2.

While the oil in the timber tank A is thus being heated, more oil is emptied from the barrels into B, and pumped thence by G through pipes *a*, *b*, into the upper tank C, ready to be rushed into A.

As soon as the temperature of the oil in the timber tank A is up to somewhat less than 212° F., the sap fluids and air contained in the timber expand in the pores and rise to the top of the oil, the air passing off with some of the oil that is also vaporized, passing into the dome *n*, from the central portion of the tank, and passing from the extremities by pipes *i*, *i*, Fig. 1.

From the dome the vapors are conducted into the condensing tank D, by the 3-inch pipe f, passing through the coils g, g, where they are condensed and carried into the wooden tank E, by the 2-inch pipe *h*, in which tank they separate by virtue of their difference in specific gravity, the water sinking to the bottom is drawn off, and the oil transferred to the tank B, and not wasted.

While this condensation is going on, cold water is continually supplied to take the place of the water warmed by contact with the coils *g*, *g*, by the pipes ∂, β, Figs. 1 and 2, from a donkey pump placed at H, Fig. 2, while the warm water passes off from the surface through the pipe ν, Figs. 1 and 2.

When the sap fluids cease to come over, the steam is cut off, a valve in the water pipe β, is closed, and the water is forced through the pipe ∂, on the top of the timber tank [∂ has small holes pierced in it to allow the water to escape from it in little jets over the surface of the tank], at the same time a valve in pipe *c* is opened, and the cold oil rushes in at the bottom of the timber tank, while the hot oil in this tank, in virtue of its less specific gravity, keeps the surface, and is discharged through what is called the "overflow pipe," marked *d*, in Figs. 1 and 2, into tank B.

As soon as the timber in the tank is sufficiently cooled, the oil in B is pumped into C, and the oil in the timber tank is transferred to B by pipes *c* and *e*; the cover of the timber tank is then removed, the movable rails *r'* *r'* replaced, the cars with their batch drawn out by shifting rope *b'*, to a moveable pulley in front of the tank; and another batch, standing already on a side track, is run in to take the place of that just drawn out, and treated in the same manner.

As dead oil congeals readily, tanks B and C are furnished with coils of small steam pipes, shown in Fig. 2, at 2 and 3, fed by a single pipe 1, Fig. 2, from the steam boiler to prevent congelation.

With this description, the drawings will enable one to understand the *modus operandi* of the Seeley process.

(To be continued.)

NICKEL AND ITS USES IN THE ARTS, COINAGE AND NICKEL PLATING.

By Dr. Lewis Feuchtwanger.

The name of nickel was given by the discoverer, Cronstedt, in 1751, in derisive manner, it having been extracted from the ore called copper nickel. The Saxon miners, in search of copper, discovered a mineral resembling copper in appearance and color, but were disappointed in not obtaining a particle of copper from it; they rejected it with the expression of a nick or copper nick, which name was then converted into copper nickel.

An English chemist found, by analysis, that the Packfong imported from China in the year 1821, but known in that country for several centuries, contained a large percentage of nickel; this discovery produced a revolution in the production of a composition in 1824, called in Germany Argentan, in France Maillechort, and in England German Silver (being first manufactured in Germany). This composition proved to be a substitute for the real silver and silver plate.

German silver in all forms and shapes was then manufactured on an extensive scale, and nickel ores were hunted up to furnish the pure metal, indispensable for the production of German silver. The United States and some European Governments thought it advisable to make use of nickel as a constituent of their small currency, which brought many millions of dollars into circulation. A few years later, in England and the United States, experiments were instituted by the silver-platers to replace the silver by pure nickel, which proved very successful, both in the expediency as well as economy. It will be seen, therefore, that nickel metal is destined to become of the greatest importance: for if we reflect for a moment to how many useful applications it has already been put, what immense consumption may be in future in store for it, and when we see how the political economy of the world must be affected by its increased uses, either as German silver, as coinage, or as substitute for silver plating, it is plain that

millions of dollars' worth of sterling silver must in future be brought into circulation which formerly were locked up in the arts.

Nickel is contained in various proportions of the following minerals, distributed over many parts of the world, such as Sweden, France, England, Scotland, Chili, the Argentine Provinces, Westphalia, Saxony, Hesse, Thuringia, and Styria; and in the United States, in the States of New York, Pennsylvania, Connecticut, Missouri; and Canada.

The most prolific source for the production of pure nickel is from the following mineral substances:

1. From the smaltine, also called smaltite; this mineral is properly cobaltiferous, being used in Saxony for manufacturing the smalts, zaffre and oxide of cobalt, and yields as a residue, after calcination, the substance called speiss, which contains 50 per cent. nickel; this, with the following two minerals, yield the supply of nickel.

2. Copper nickel is an arsenical nickel, called by modern mineralogists niccolite, or arsenical pyrrhotite; it contains about 45 per cent. nickel, and 50 per cent. arsenic.

3. Millerite, which is a sulphide of nickel, contains 65 per cent. nickel, and 35 per cent. sulphur; it is found in two forms in nature, crystalline and capillary millerite; it is found in capillary crystals, in cavities of other minerals, as at Antwerp, New York, with spathic iron, in radiated or fibrous crystalline forms, found in considerable quantities at the Gap mine, in Pennsylvania.

4. The Pyrrhotite, also called Troilite, which is, properly speaking, a sulphide of iron, in a massive condition, contains but a very small proportion of nickel, only from 3 to 6 per cent.; it is nevertheless used as a material for extraction of nickel.

Pyrrhotite, also called nickeliferous pyrrhotite, is, on account of its abundance over the world, mostly employed—in Sweden, Norway, Spain, Cornwall in England, and in numerous localities in the United States, such as in Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Tennessee, and Canada.

Many more minerals are found in which nickel is associated with cobalt, copper, arsenic, antimony, bismuth, sulphur and iron; but the most interesting occurrence is in the meteorite or meteoric stones which are occasionally thrown on the earth by celestial bodies, of various sizes, and which contain from 1 to 20 per cent nickel, and from 80 to 90 per cent. iron, with about ten other constituents of small percentage. Some of these masses are of considerable weight.

The specimen in the Smithsonian Institute at Washington, called the Tucson Meteorite, weighs 1,400 lbs.; one in Yale College weighs 1,635 lbs. Some masses, fourteen specimens in number, found in Texas, near the border of Mexico, a few years ago, weigh in the aggregate about 5,000 lbs., some from 3 to 500 lbs. each. I have in my own collection about twenty specimens, found in Tennessee, Wisconsin, Poland, Zacatecas, Mexico, and containing from 10 to 15 per cent. nickel.

The production of pure metallic nickel.—Several methods have been recommended by Berthier, Wohler, Liebig and others, for refining either the speiss or copper nickel; that of Liebig appears to be the more simple; the nickeliferous ore, whether it is speiss or copper nickel, is coarsely ground and roasted, and then mixed with half its weight of ground fluorspar, and this mixture is treated hydrochemically by adding three times as much of oil of vitriol in a leaden vat with gently heating, under constant agitation; the dry and hard mass is then broken up in small pieces and calcined in a reverberatory furnace, and then dissolved in hot water, whereby the sulphate of lime is removed; all the metals are now separated in the following manner: the mass containing the metals is dissolved in a mixture of sulphuric and nitric acid, and the solution left over night for crystallization; all the crystals are now dissolved, when the iron contained in the liquid is precipitated by a carbonate of soda; the second metal or copper is precipitated by passing sulphuretted hydrogen gas for several hours, and in order to separate the cobalt from nickel, chlorine gas is used to dissolve the oxide of nickel, leaving cobalt untouched.

The chloride of nickel may now be converted into sulphate or carbonate by the bicarbonate or caustic soda, or converted into sulphate of nickel and evaporated to dryness and calcined. In order to reduce the calcined salt to metal, it is mixed with charcoal and some flux as ground fluorspar and exposed to intense heat. When the regulus is left on the bottom of the crucible, it is sufficiently pure for all purposes of alloying, but by exposing the carbonate to a jet of hydrogen gas, the metallic nickel is obtained chemically pure.

The millerite from the Gap mine in Pennsylvania and the accompanying ore, the pyrrhotite, are now mostly operated on for the production of pure nickel. The first contains 63 per cent. nickel and 35 per cent. sulphur, the remainder being of iron, copper and cobalt; while the pyrrhotine contains but 6 per cent. nickel. These ores are treated either in the way just described, or by a late method pro-

posed, which is the following: To mix the coarse powder with iron filings and nitro-muriatic acid, the solution evaporated to dryness, and then dissolved in water and treated with sulphuretted hydrogen for precipitating the copper; and after filtration boil with nitric acid, to deoxidize the iron; after diluting the liquid with much water, carbonate of soda is now employed, and the carbonate of nickel reduced in the manner described.

For making an alloy of the nickel metal, it is only necessary to evaporate to dryness the solution of sulphate of nickel, and then heating it at a high temperature, to reduce the oxide of nickel by charcoal at high heat.

There are several other methods recommended by Tupputti, Berthier and others, for procuring a pure metallic nickel from speiss or copper nickel, aiming mainly to the complete separation of cobalt and arsenic, which give much trouble, while the other admixtures of sulphur, copper and antimony, iron and manganese, may readily be separated. All the salts of nickel are protoxides; the salts are yellowish, and are decomposable by heat, though some exert a greater resistance than others; sulphuretted hydrogen gives no precipitate in acid solutions. The protoxide of nickel is obtained as hydrate by precipitating a salt of nickel with a caustic alkali; and calcination of the nitrate yields the anhydrous oxide, and is green when hydrated, and gray when anhydrous.

Chlorine forms with nickel both a hydrated and anhydrous compound. The first is obtained by evaporating the solution of the oxyde, as carbonate, in hydrochloric acid to crystallization; and the latter by passing dry chlorine over the metal heated to redness, or by slightly calcining the hydrated chloride. *Sulphate of nickel* forms green crystals, which lose transparency by gentle heat. *Nitrate of nickel* forms, likewise, bluish-green crystals, efflorescent in dry and deliquescent in moist air, soluble in water and alcohol, and gives with ammonia bright-blue, soluble crystals.

The *emerald nickel* is a native mineral found encrusted on chromic iron at Texas, Lancaster Co., Pa., and is a hydrated oxide of nickel.

Nickel metal has a white color, intermediate between that of silver and tin, has a lustre between steel and platinum, takes a high polish, is perfectly malleable, may be forged when hot into bars and hammered into plates when cold. It is very ductile, and may be drawn into fine wire. Its specific gravity is 8·28, and when forged, 8·7; conducts heat, obeys the magnet, and is itself capable of becoming

magnetic, but it loses its magnetic property when heated to 350° ; it retains, however, the same whenever alloyed with arsenic.

The characteristics of the metal nickel were but little known in the beginning of this century, when it was thought to be a modification of *iron*, on account of its magnetic property; while others supposed it to be an alloy of copper.

Nickel alloys.—There are three useful alloys with nickel:

1. The Meteoric Steel: it contains a very small proportion of nickel to steel; it is extremely hard, susceptible of taking a high polish, and an appearance of damask, if treated with acids.

2. The German silver or argentan, or Chinese copper—Packfong. This alloy has been known in China for several centuries, and many utensils were there manufactured of it; but the composition was not known in Europe until the year 1821, when samples were brought to England and analyzed by Dr. Fyfe, who made known the contents, being 40 per cent. copper, 32 per cent. nickel, 25 per cent. zinc, and 3 per cent. iron. This information induced many manufacturers in England and Saxony to utilize the refuse from the cobalt mines in Sweden and Saxony for the production of the pure nickel, and particularly at the Royal Blue Smatt Works, where the speiss had been accumulating for several centuries and thrown away as useless. The imitation of silverware for the household was now begun on a very extensive scale in Sheffield and Birmingham, England, and Schneeberg in Saxony. Table furniture, such as tea, table and dessert spoons, forks and knives, German silver sheet and wire, and German silver castings for gun mountings were then introduced in market, in imitation of silver patterns, and very fine wares were brought from the manufacturers and exported to all parts of the world.

The price of German silver was regulated by the quantity of nickel which was consumed in the production of a good alloy with copper and zinc. The best mixture for white metal, in order to be rolled out in sheets and bars, was then made of 20 per cent. nickel, 60 per cent. copper, and 20 per cent. zinc, and in this proportion the writer began, in 1834 to 1839, to manufacture German silver in this city, for which purpose he imported from Germany many tons of the crude material and refined therefrom the pure nickel, producing a fine white metal, which was eagerly purchased by many mechanics. He himself received for several years silver medals from the American Institute at its fairs, exhibiting at one exhibition 150 different articles for the household, and knobs, hinges, stirrups, trumpets, napkin-rings, etc.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, April 16, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting held April 9th, 1873, the following donations had been received into the Library:

On the Short-Footed Ungulata of the Eocene of Wyoming. From Edward D. Cope.

On some Eocene Mammals obtained by Hayden's Geological Survey of 1872. From the same.

U. S. Patent Office Reports for the years 1869, 1870 and 1871. From the Commissioner of Patents.

Quarterly Weather Report of the Meteorological Office. From the Meteorological Committee, London.

Memoir of the Founding and Progress of the U. S. Naval Observatory. From Rear Admiral B. F. Sands, U. S. N.

Proceedings of the American Philosopical Society. From the Society.

Annales de Chimie et de Physik. From the Publishers, Paris.

Comptes Rendus Hebdom. des Séances de l'Academie des Sciences. From the Academy.

Moniteur Scientifique for 1870 and 1871. From M. Dr. Quesneville, Paris.

Bulletin Mensuel de la Société Chemique de Paris for 1870. From Chas. Barreswil, Esq.

Monthly Notices of the Royal Astronomical Society for February, 1873. From the Society.

Report on the Preservation of Wood, with tabulated results of the examination of all the best known methods; conducted by Dr. B. F. Craig, U. S. A.

Notes, Historical and Statistical, upon the Projected Route for a Ship Canal between the Atlantic and Pacific Oceans. From S. T. Abert, C. E.

Annales des Mines—January and February, 1873. From the Editor.

Annales des Ponts et Chaussées—January and February, 1873. From the same.

U. S. Patent Office Reports for 1868. From the Hon. Commissioner of Patents.

Journal of the Statistical Society of London for December, 1872. From the Society.

Journal of the Society of Arts of London for February, 1873. From the Society.

Notes on the Practical Gauging of Rivers. From Bvt. Brig. Gen. Henry L. Abbot, U. S. A.

Report of the Committee on Fire Patrol of the Chicago Board of Fire Underwriters. From the Board.

Report of the Fire Marshal of the Board of Fire Underwriters of the City of San Francisco. From the Fire Marshal.

Report of Progress for 1871 and 1872 of the Geological Survey of Canada. From the Director of the Survey.

Journal of the United States Centennial Commission. From the Commission.

Proceedings of the Academy of Natural Sciences, Philadelphia, December, 1872. From the Academy.

The Actuary further reported the passage of the following resolution by the Board of Managers, viz. :

"*Resolved*, That, in accordance with the recommendation of the Committee on Science and the Arts, the Scott Legacy Medal and Premium be awarded to William Wharton, Jr., for his invention of a Safety Switch for Railroads."

The President then called for the reports of special committees. The Committees on the Horse-Power of Steam Boilers and on Conflagrations reported progress and were continued. The Committee appointed to fix upon a Factor of Safety in Carrying Steam Pressure, presented the following report :

"The Committee to whom was referred the inquiry for some rule for the thickness of shells of cylindrical steam boilers, ask to report : That the subject has been previously investigated by numerous writers, and the general conclusion appears to be that the 'factor of safety' is ordinarily taken at 6 ; or that the working pressure is not allowed to exceed one-sixth of the bursting pressure. Sir William Fairbairn derives as a result of his experiments on strength of materials and of joints : 'Wrought-iron plates with single rivetted joints = 34,000 lbs. per square inch tensile strain, as maximum average strength ; and from these data finds the maximum working strength should be 5,668 lbs. per square inch.' Your Committee, from practical knowledge of the thicknesses usually assumed by the best boiler makers, think 6,000 lbs. more nearly agrees

with American construction. As the factor of 6 is a large one, and as Fairbairn, in his value of 34,000 lbs., has made some allowance for reduction of strength in jointing, which may properly be taken as a part of the contingencies that the six should cover, the Committee believe that 6,000 lbs. can be safely taken for the basis of estimate of the working strength of cylindrical surfaces of steam boilers.

"Signed, ROBERT BRIGGS,
W. BARNET LEVAN,
W. F. DURFEE,
L. SCHUTLE, *Committee.*"

Upon motion, the report was accepted, and the Committee discharged from further consideration of the subject.

The President next announced a paper upon Bridge Building Considered Normally, by John Murphy, Engineer. The same will be found in full in the *Journal of the Franklin Institute.*

Dr. Robert E. Rogers next presented some remarks upon the proper manipulation of gases for the lantern, and exhibited and described an improved apparatus for this purpose.

Dr. Chas. M. Cresson offered some remarks upon the employment of the spectroscope in the laboratory, and exhibited in operation an improved and very convenient arrangement of this instrument for laboratory use.

The Secretary next presented his monthly report upon Novelties in Science and the Mechanic Arts.

Under the head of new business, Mr. S. Lloyd Wiegand presented the following:

"The rapidly increasing use of screwed tubing in steam and water apparatus, raises to importance the determination of the best proportions for, and means of producing screw-threads thereon.

"There is a want of uniformity in the pitch, or number of threads per inch, on tubes from different makers; also differences in the diameter of screws nominally the same.

"Difficulty and loss of time in screwing together parts supplied by different makers is not unusual, and badly fitted jobs are frequently chargeable to variations of standard and gauge.

"The extensive use of thin lap-welded tubing, originally designed for boiler flues for the water and steam containing portions of sectional steam generators, has within the last few years grown into a large business, as has also the employment of the same material for artesian well purposes.

"The threading of such tubes is limited in depth by the thickness of the material, and the sharp edged, or V shaped threads, when so applied, must be of very fine pitch to avoid weakening the tube below safe limits at the base of the threads.